Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

D EMPIRE BUILDING · JUNE, 1946 · PITTSBURGH, PA.

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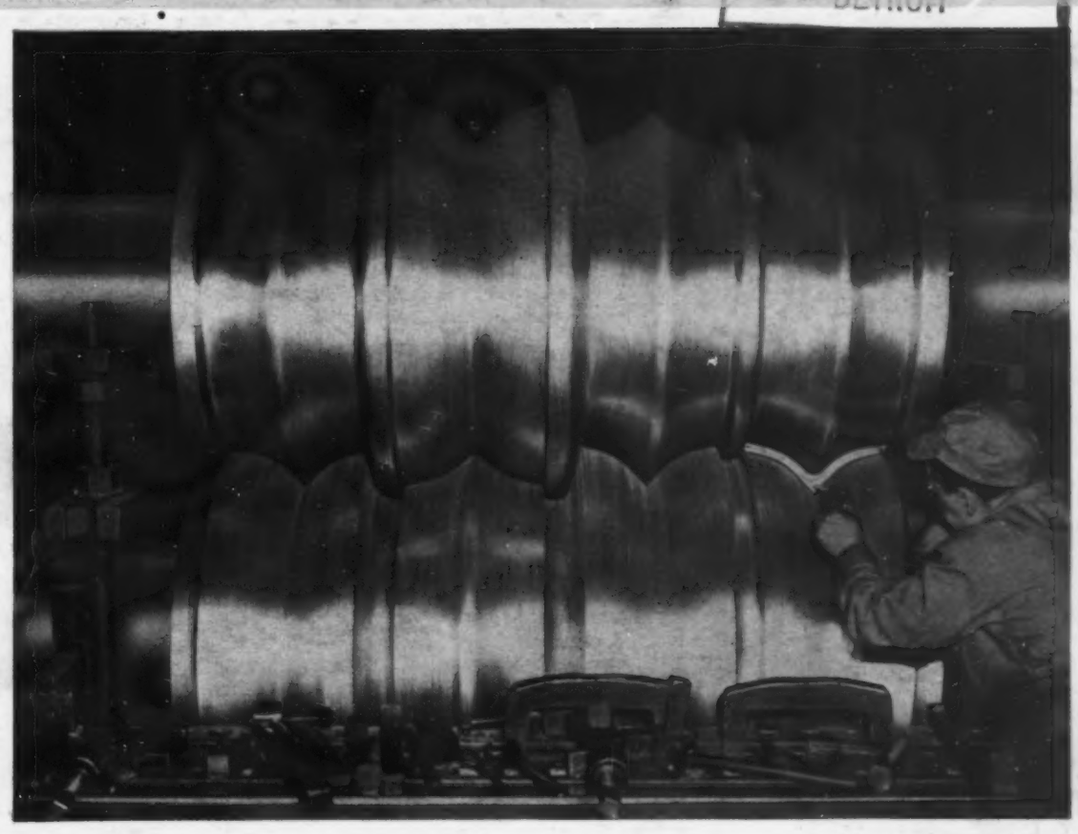
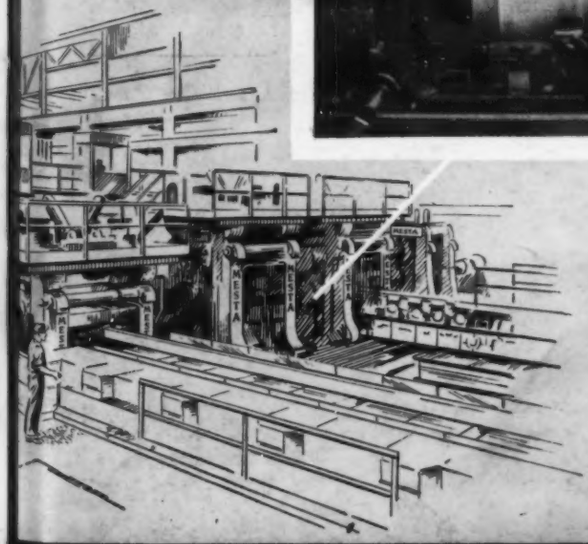
DETROIT

NOLOGY DEPT.

MESTA ROLLS





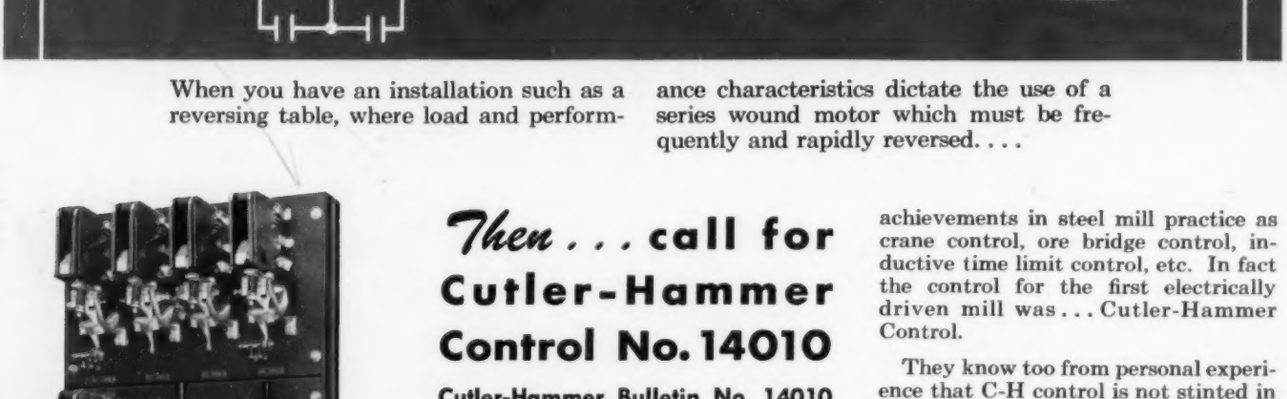
MESTA SPECIAL ALLOY STEEL 29 INCH STRUCTURAL MILL

INTERMEDIATE ROLLS FOR ROLLING 8″ x 8″ ANGLES

MESTA MACHINE COMPANY · PITTSBURGH, PA.

What control for what mill equipment? One of a SERIES of advertisements featuring basic heavy duty power circuits . . . and showing Cutler-Hammer's broad design and application experience which has made it *the* preferred control for the steel industry.

D. C. reversing plugging control



When you have an installation such as a reversing table, where load and performance characteristics dictate the use of a series wound motor which must be frequently and rapidly reversed. . . .

Typical Components of Cutler-Hammer Mill Control

Then . . . call for Cutler-Hammer Control No. 14010

Cutler-Hammer Bulletin No. 14010 offers the following advantages:

LtI ACCELERATION.... Cutler-Hammer Inductive Time Limit Control, a pioneering development of this company, accelerates all loads alike, smoothly, safely, uniformly. The simplest accelerating system, eliminating relays, dashpots and other parts that commonly give trouble.

PLUGGING PROTECTION.... gained without the need of auxiliary relays, typical of the simplicity of Cutler-Hammer design.

EQUIPMENT.... Conforming to NEMA standards. Available in ratings up to 1800 amperes. In open, enclosed or complete factory assembled ready to wire units. A complete line of control accessories.

USERS PREFER CUTLER-HAMMER CONTROL because they know Cutler-Hammer as the oldest in control specialization, pioneering such important achievements in steel mill practice as crane control, ore bridge control, inductive time limit control, etc. In fact the control for the first electrically driven mill was . . . Cutler-Hammer Control.

They know too from personal experience that C-H control is not stinted in any of its parts, that in every detail Cutler-Hammer control is *engineered* control, *by* engineers *for* engineers.

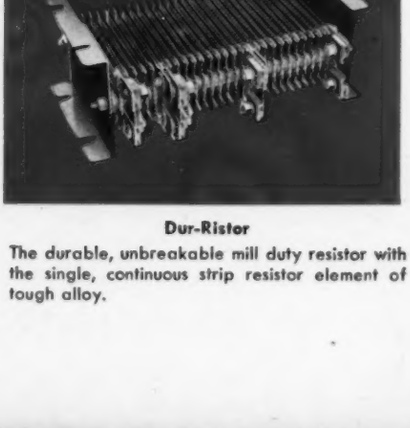
Finally, users have found constant betterment, constant improvement. Quality has never slipped back, has never long stood still, has always moved forward.

These are some of the reasons why so many men in steel say: "Give me C-H control every time." CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

CUTLER-HAMMER
MOTOR CONTROL
C-H

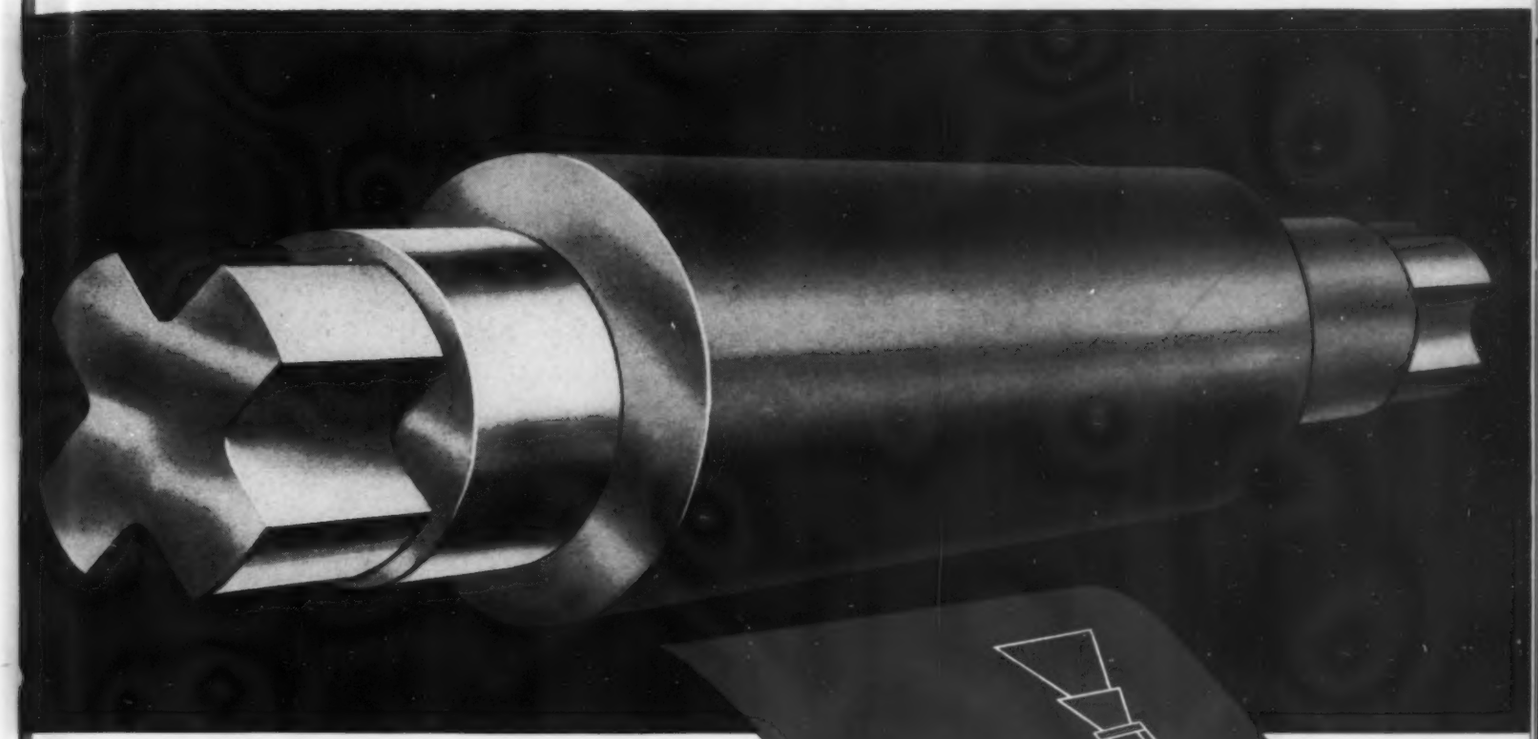
Mill Contactor
The mill-type contactors whose reliability, life and low maintenance have made them the standard for the industry.

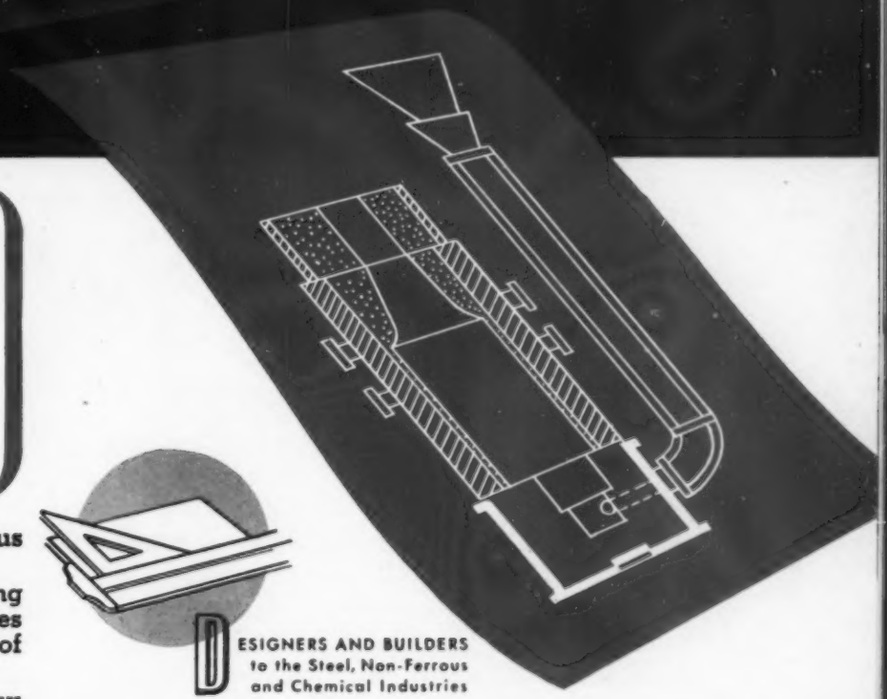
Mill-Master (Cover removed)
Compact construction with cam-operated twin break contacts. Preferred because of its ease of operation.



Dur-Ristor
The durable, unbreakable mill duty resistor with the single, continuous strip resistor element of tough alloy.

Experience Available in ROLL *Form*





SIZES

- There is an Aetna-Standard Size and Type of Roll for Every Purpose.
- from rolls for an 8-inch mill, all intermediate sizes, up to large plate mill rolls, 34″ x 206″.

PLAIN CHILL	ALANITE
MOLY CHILL	GRAIN
NICKEL CHILL	ASEX
ALANITE SPECIAL	ASEX SPECIAL

Forming, Welding, and Sizing rolls for steel pipe, rolls for rubber and plastic mills.

You buy rolls from experience . . . your own plus ne experience of the maker of rolls.

Your experience dictates which rolls are producing ne most tonnage. Our 34 years of experience guides s in recommending the right analysis and type of oll for your specific job.

You know your job. We know ours. When you buy etna-Standard Rolls you are buying 34 years of exerience in designing and casting iron-base rolls.

We have the facts, the figures, and the rolls. Call n Aetna-Standard for sound roll information and ound rolls.

DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries

THE AETNA-STANDARD ENGINEERING CO.

YOUNGSTOWN, OHIO

ASSOCIATED COMPANY

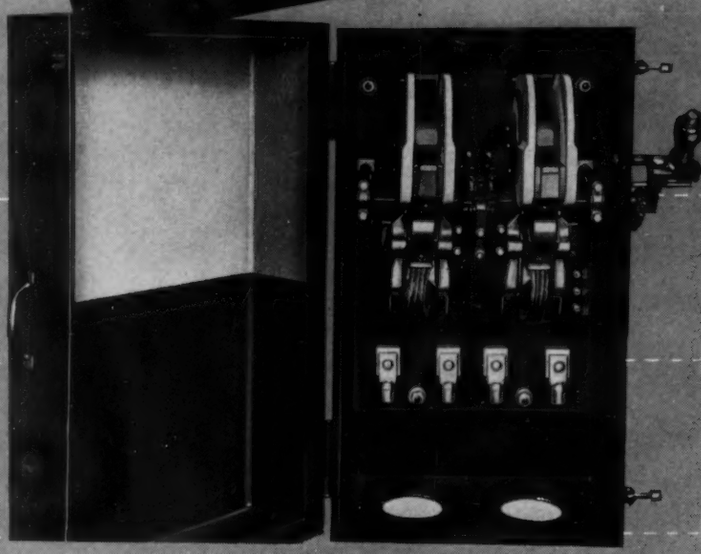
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND

ROLLS *by*

Aetna-Standard

Now—two more sizes of this

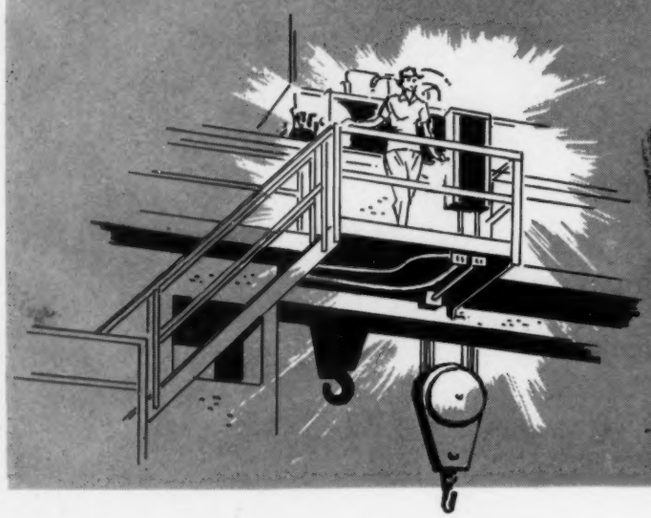
new Safety Disconnect Switch for D-c Cranes



1 Manual-magnetic type for ease of operation.

2 LINE-ARC design for high arc-rupturing ability.

3 Designed with parts associated with crane control to reduce the replacement-part problem.



● Safety rules in many industrial plants and laws in several states require a safety disconnect switch on overhead traveling cranes, mounted at the point where the operator enters or leaves the crane. These switches disconnect the crane from the main collector power-feeders running along the crane runway.

Previously, operators, especially women, have had difficulty in opening and closing disconnect switches of the manually operated type.

This new EC&M *Magnetic Type* Disconnect Switch meets all the requirements of ease of operation, safety, convenience and reliability. It is of double pole design, completely enclosed and has side-type, externally-operated handle with thumb-latch which holds handle in either open or closed position. Pushing the handle up closes the switch, pulling it down opens it—a cam roller forces contacts open, if necessary, and also insures against accidental closure due to vibration or an impact blow from another crane on the same runway. It allows for up to three padlocks for locking switch open.

New publication 1024, just issued, gives complete data on ratings, sizes, dimensions, etc. Copy will be mailed promptly upon receipt of your request.

Due to popular demand, two additional sizes of these disconnect switches are now available, making a total of four sizes to suit cranes of different capacities.

E&M

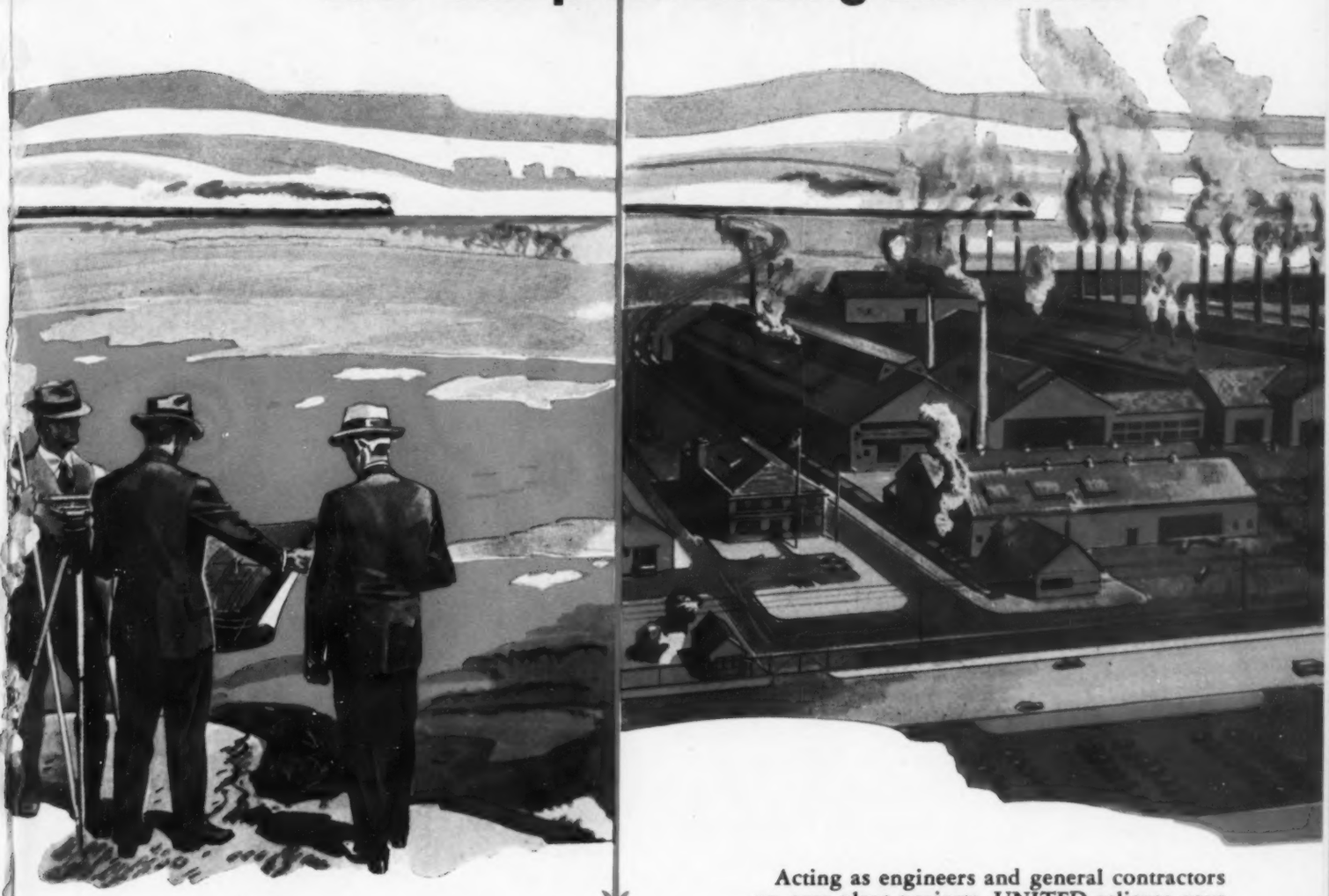
THE ELECTRIC CONTROLLER & MANUFACTURING CO.

2698 EAST 79th STREET • CLEVELAND 4, OHIO

From Site Survey To Point of Production . . .

UNITED

will Design, Build and Equip Your Complete Rolling Mill Plant



Acting as engineers and general contractors on new plant projects, UNITED relieves your own organization of all construction and equipment problems.

Given basic requirements, UNITED will:

- **Survey your site.**
- **Erect all structures.**
- **Design, build and install all the machinery and equipment necessary to turn the plant over to you ready for operation.**

This complete UNITED service integrates all new plant construction details under one contract with responsibility vested in a single qualified organization. It is available to companies *the world over* whose new plant projects involve the rolling of ferrous, non-ferrous or even non-metallic materials.

REG. U. S. T. M.

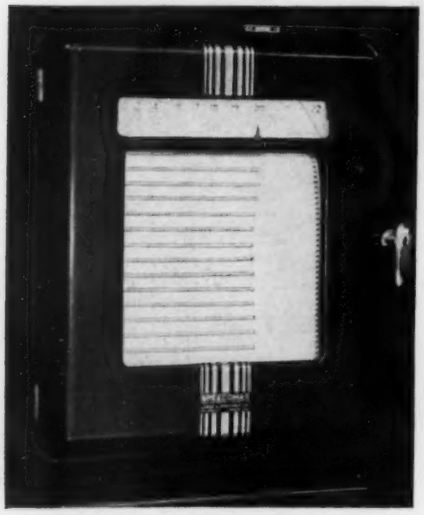
NITED ENGINEERING and FOUNDRY COMPANY

Pittsburgh, Pennsylvania

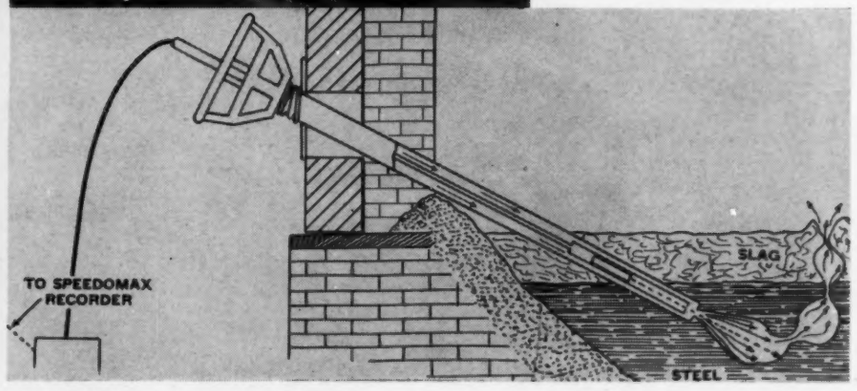
Plants at Pittsburgh • Vandergrift • New Castle • Youngstown • Canton
Subsidiary: Adamson United Company, Akron, Ohio
Affiliates: Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal, P.Q. Canada

The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment

Operator prepares to plunge Immersion Rayotube into Open-Hearth bath.



Immersion tube in operating position, showing Rayotube sighting directly on hot metal. Speedomax instrument at left instantly records metal temperature.



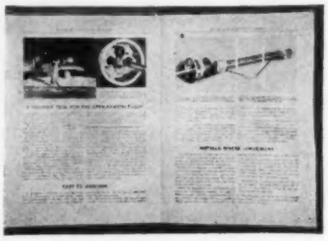
NEW! IMMERSION RAYOTUBE Measures O-H Bath Temperature

A Rayotube which can be thrust through the slag and into the steel bath of an open hearth furnace is now available. It solves the long-time problem of measuring the temperature of molten steel before it leaves the furnace — while the reading can still be used in preparing the heat for tapping.

By giving such timely information, the Immersion Rayotube Pyrometer, as the device is called, makes possible better product and greater operating efficiency in the steel mill.

It may even help to open up a new vista of understanding of the chemistry of steel making, since it gives the metallurgical department permanent records of facts which it will wish to accumulate and study, while both metallurgists and open-hearth operating force can use the information for instant, effective readying of each melt.

Write us for further details. We'll be glad to send this Folder N-33B-643(1), completely describing the Immersion Rayotube Pyrometer, or an L&N engineer will call, as you prefer.



LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA. 44, PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Ird Ad N-33B-643(4)

HAVE YOU considered using *GRAPHITE* TUBES for the introduction of gases for purifying and cleaning your molten metal? "National" graphite is ideal for this job for two basic reasons:

1. ***It has unusually long life.*** Graphite cannot melt away—actually has *no* melting point! Graphite is strong—it is unharmed by violent changes in temperatures. It retains its strength even at highest temperatures. And it will not corrode, regardless of the gases used.

2. ***It will not contaminate the metal.*** Graphite will not go into solution or otherwise cause inclusions in castings. Also, a graphite tube comes out *clean*—Molten metal will not stick to graphite!

You can get the full story on "National" graphite tubes from our nearest Division Office.

The word "National" is a registered trade-mark of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

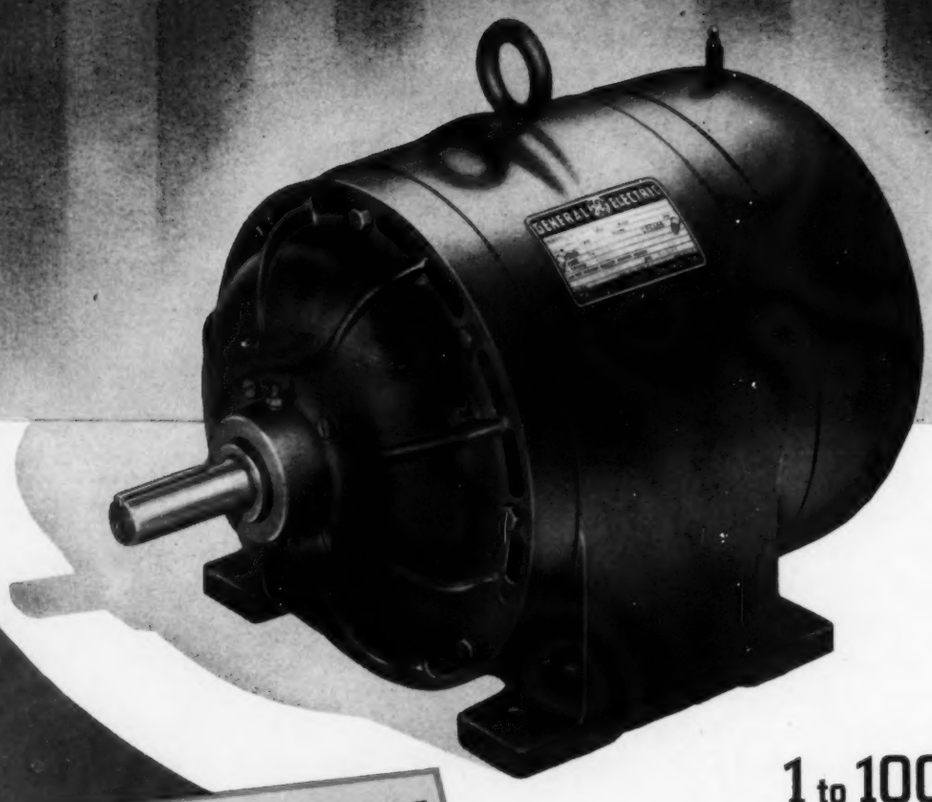
30 East 42nd Street, New York 17, N. Y.

Division Sales Offices: **Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco**

33-143A 7 x 10 Trade 2-21-46 P3

GENERAL ELECTRIC

Announces:



1 to 1000 hp

COMPLETE ENCLOSURE
FOR PROTECTION
AGAINST DIRT, DUST,
AND WEATHER

NEW

Totally Enclosed

TRI/CLAD MOTORS

REG. U.S. PAT. OFF.

In 1940, G.E. introduced the Tri-Clad open motor—with emphasis on the feature that industry wanted most in a motor, *protection.* Since then, more Tri-Clads have gone into service than any other integral-horse-power motor.

Today, we are ready with a new line of Tri-Clad motors—*totally enclosed, fan-cooled motors*—built on Tri-Clad design principles in both standard and explosion-proof types.

We believe that these are industry's most dependable motors. They are designed specifically for use in many adverse atmospheres—in iron dust, outdoors, in hazardous areas, and chemical atmospheres. Their scope of application is as wide as the field of industrial motor use. Safeguarded against most sources of motor damage, their longer life and lower maintenance will make them economical motors for use on almost every job. *General Electric Company, Schenectady 5, New York.*

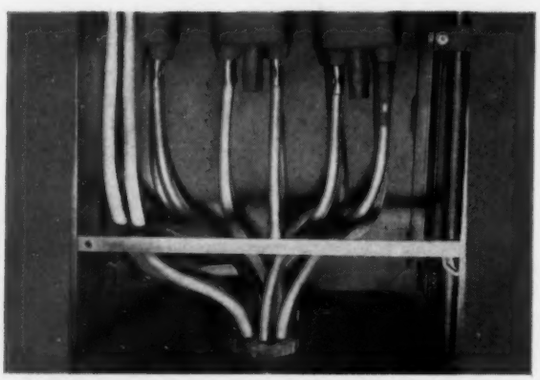
GENERAL ELECTRIC

TRI/CLAD MOTORS

WIRE and CABLE USERS

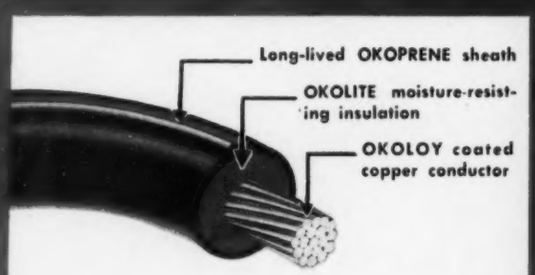
WROTE OWN "SPECS" for RESEARCH LABORATORY

Before equipping their new and completely modern laboratory, the engineers of a world-famous research organization decided to write their own specifications. Drawing on the extensive experience and test results of their own, they called for wires and cables insulated with an oil-base compound protected by a sheath of neoprene. *They knew what they wanted:*—wiring that would resist flame, moisture, heat and chemicals. *They GOT what they wanted:* — Okolite-Okoprene* cables shown in pictures below. The job is described in Bulletin OK2035, the cable in Bulletin OK2009-C both available on request. The Okonite Company, Passaic, N. J.



Connections for one of three 208-volt ring mains in cellar of laboratory at low side of 4150 volt distribution transformer. The 4/0 Okolite-Okoprene cables are colored blue, red and black for phase identification.

Taps being made in 3' x 3' distribution manhole. Exposed section of conductor and connector insulated with Okonite splicing materials. Okolite-Okoprene cables were specified for tough, damp locations.



OKOLITE-OKOPRENE cables offer such additional advantages as:— no braids to rot . . . simple, flexible, long-lived construction . . . tough weather-resistant jacket of uniform thickness requiring no other covering . . . high surface resistance that eliminates surface discharge . . . 75°C operation.

OKONITE RUBBER TAPE AND MANSON FRICTION TAPE offer a combination known the world over for dependable protection and high quality in jointing and splicing operations. Okolite High Voltage Corona-Resisting Tape and Okonite Cement help round out a complete line of tapes and splicing materials. For additional data, write for Bulletin 1007.

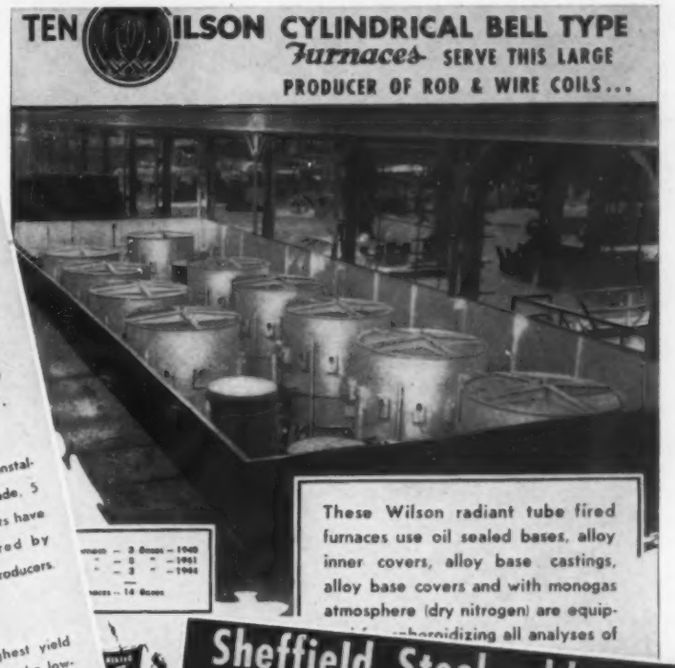
*U. S. Pat. No. 2,312,058

OKONITE insulated wires and cables

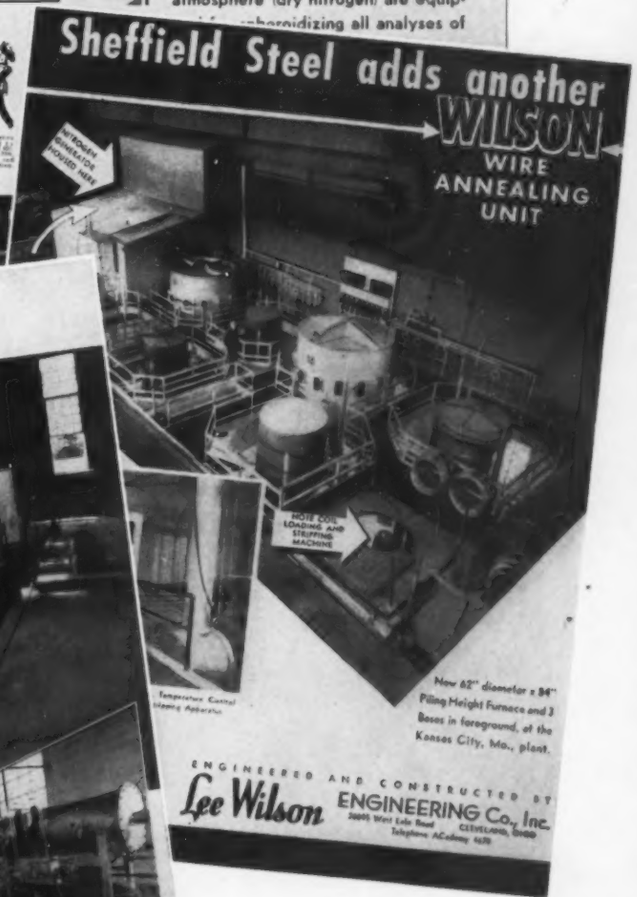
Every WILSON WIRE ANNEALING INSTALLATION IS ENGINEERED TO FIT YOUR SPECIAL NEEDS ★

Bell Type Furnaces Radiant Tube Fired

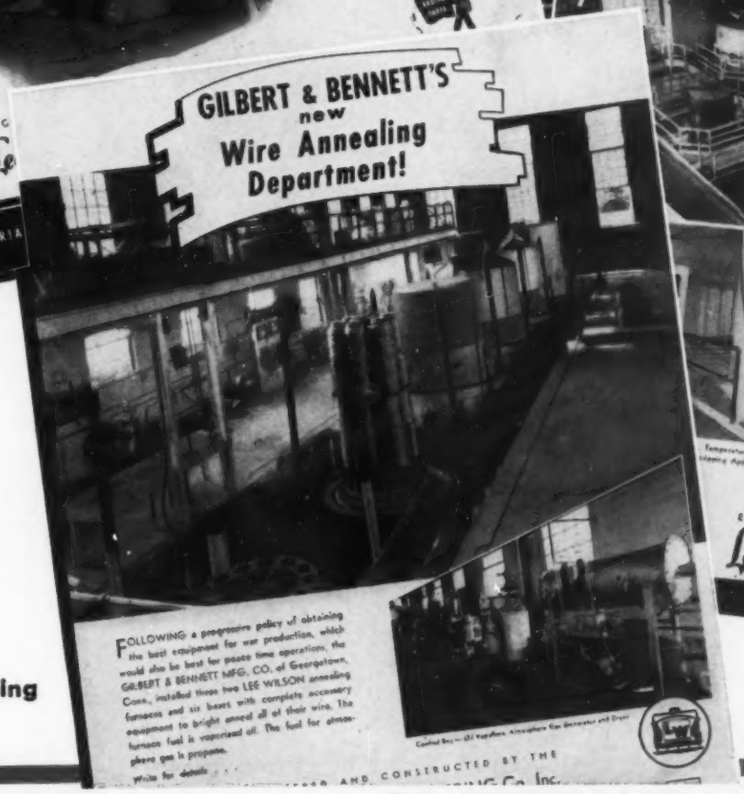
Rod Coil Spheroidizing


TEN WILSON CYLINDRICAL BELL TYPE Furnaces SERVE THIS LARGE PRODUCER OF ROD & WIRE COILS...
These Wilson radiant tube fired furnaces use oil sealed bases, alloy inner covers, alloy base castings, alloy base covers and with monogas atmosphere (dry nitrogen) are equip-

This WILSON BELL TYPE Furnace IS BEING LOWERED OVER ANOTHER HEAVY CHARGE at the WILSON STEEL & WIRE COMPANY'S Chicago Plant.
FURNACE CHARGE SIZE— 74" Diameter 84" Piling Height
Load—18,000 Lbs. of Wire
SINCE this installation was made, 5 additional units have been ordered by other wire producers.
THE highest yield per hour at the lowest fuel rate—
Average Load—18,000 Lbs.
Average Time—8 Hours.
Average Fuel Rate—1,100,000 BTU Ton.


Sheffield Steel adds another WILSON WIRE ANNEALING UNIT
NITROGEN GENERATOR HOUSED HERE
NOTE COIL LOADING AND STRIPPING MACHINE
Temperature Control Steering Apparatus
New 62" diameter x 84" Piling Height Furnace and 3 Bases in foreground, at the Kansas City, Mo., plant.
ENGINEERED AND CONSTRUCTED BY
Lee Wilson ENGINEERING Co., Inc.
20005 West Lake Road CLEVELAND, OHIO
Telephone ACademy 4670

Heavy Production Process Wire Annealing


GILBERT & BENNETT'S new Wire Annealing Department!
FOLLOWING a progressive policy of obtaining the best equipment for war production, which would also be best for peace time operations, the GILBERT & BENNETT MFG. CO. of Georgetown, Conn., installed three two LEE WILSON annealing furnaces and six bases with complete accessory equipment to bright anneal all of their wire. The furnace fuel is vaporized oil. The fuel for atmosphere gas is propane.
Write for details

Fine Wire Annealing

Miscellaneous Merchant Wire Annealing

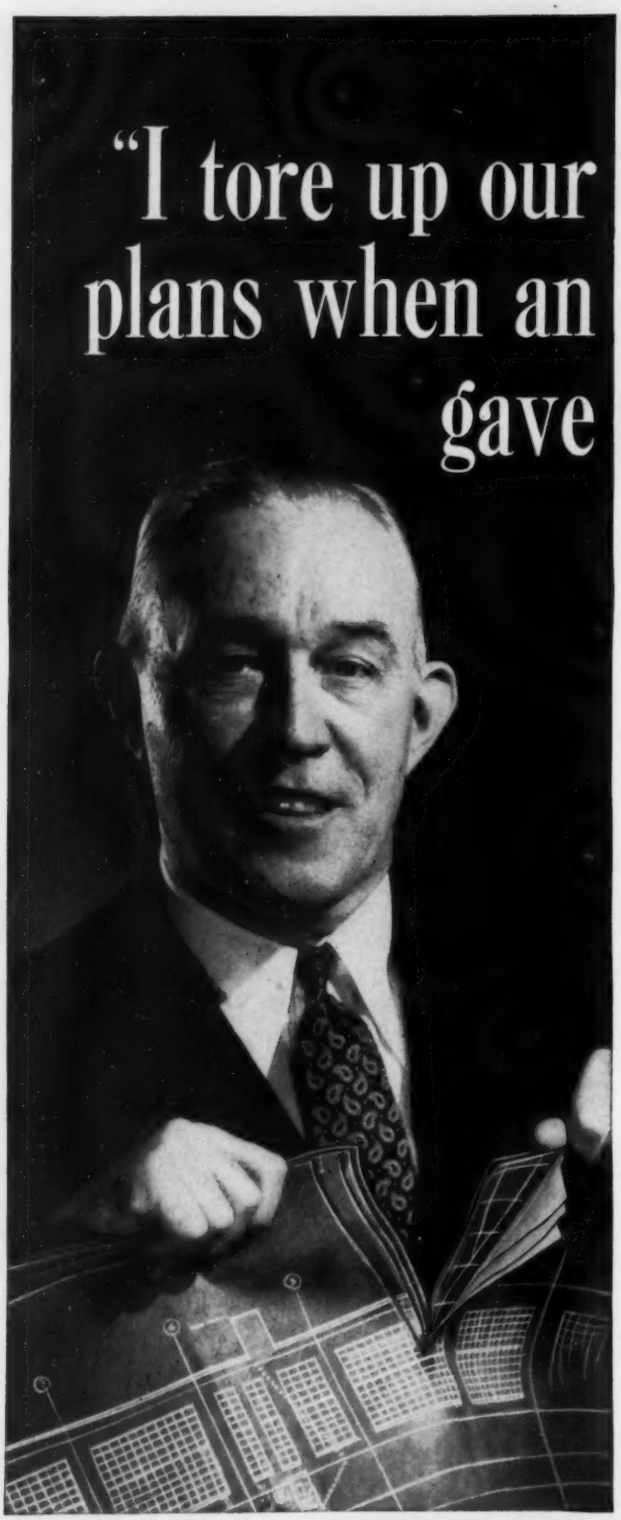
ENGINEERED AND CONSTRUCTED BY THE

Lee Wilson ENGINEERING Co., Inc.

20005 West Lake Road CLEVELAND, OHIO

Telephone ACademy 4670

INDUSTRIAL FURNACES ★ RADIANT TUBE HEATING ★ HEAT TREATING PROCESSES



"I tore up our new warehouse plans when an A.T.C. Specialist gave us 50% more FREE Storage Space

...AND CUT OUR HANDLING COSTS 30% IN THE BARGAIN!"

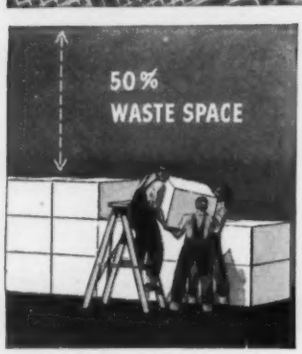
Yes, many a plant owner has saved himself the cost of a new warehouse because he let an A.T.C. material handling Specialist make a survey of his material handling costs.

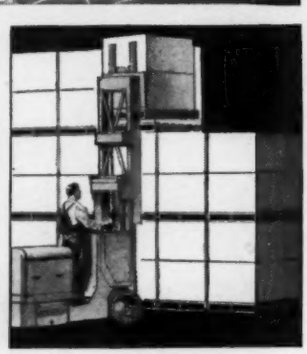
Manual methods of storing raw and finished products often waste as much as 50% storage space. In the diagram to the left, see how much free storage space you can add to your present plant's capacity—how you take the work out of the job for your help, release more workers for more productive work.

An A.T.C. Specialist will show you how this can be done by efficient movement of your materials on Automatic Electric Trucks from receipt of raw materials through each successive handling procedure to storage and final shipment. These trucks are time-tested, brawny giants of electric power that lift, move and stack 1 to 30 tons with simple one-man operation.

They move through narrow aisles, turn sharp corners, go up and down grades whenever necessary. They speed up production, cut overall handling costs 30% to 60%, lighten labor's load.

Let an A.T.C. Specialist tell you what *your* handling costs are—what you can save with Automatic Fork Trucks. No obligation. Send coupon.





Automatic
ELECTRIC TRUCKS
Lighten LIFE'S LOADS

AUTOMATIC TRANSPORTATION COMPANY
47 W. 87th Street, Dept. F, Chicago 20, Ill.
Please mail me, without cost or obligation, complete facts about AUTOMATIC FORK TRUCKS.
( ) Have an A.T.C. Material Handling Specialist call.

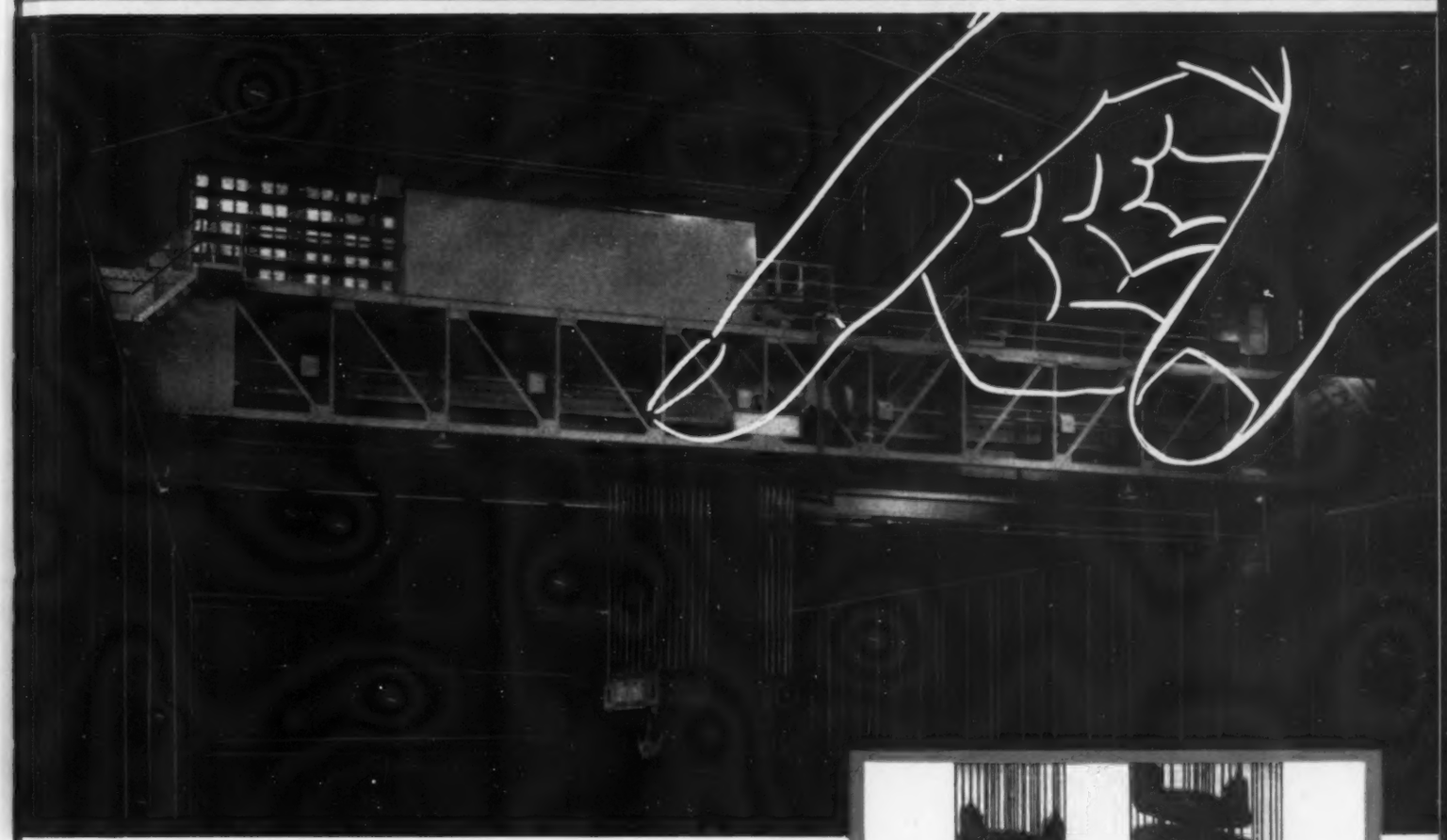
Company Name.....

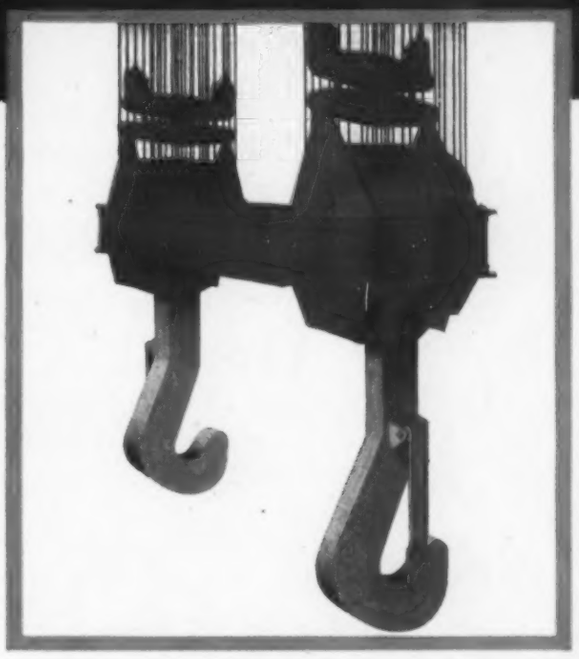
By.....*Position*.....

Street Address.....

City.....*State*.....

Putting the finger on Safety *IN ALLIANCE CRANES*





ROPES Liberal factor of safety—Minimum drum and sheave diameters are 30 times the diameter of the rope. Fleet angle is kept to a minimum.

GEARS To take care of overloading, gear teeth are designed with high factor of safety and low tooth pressure. All gears enclosed and running in a bath of oil.

CABS Adequate visibility . . . plus convenient location of controls. Steel footwalks with hand rails. Stairways leading to cab and to top of bridge. Ladle cranes are equipped with a safety compartment in the operator's cab. This compartment contains a duplicate bridge controller, which enables the operator to move the crane in safety in case of accidental spilling of hot metal.

HOIST ROPES Alliance ladle cranes carry the load on four, not one, independent main hoisting ropes, which is one of the features of our patented safety rope reeving for ladle cranes.

During 45 years in the business of building cranes, Alliance has developed many new Safety and Mechanical features, which are now incorporated as standard practice in Steel Mill Cranes.

THE ALLIANCE MACHINE COMPANY, ALLIANCE, OHIO • PITTSBURGH, 1622 OLIVER BLDG.

CONSULT ALLIANCE ON CRANES

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS
SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET
CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES
SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

Alliance

"The Mill Operator Who Threw Caution to the Winds."

THERE once was a steel mill operator who was very particular about "safety margins." While he knew that he was losing valuable production time in reversing his huge blooming mill, he really believed that careful practice required long operating cycles.

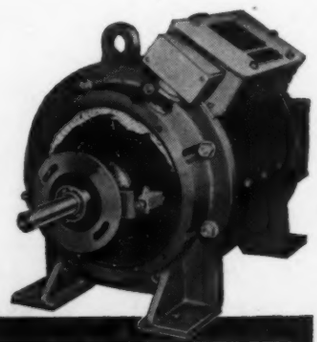
Then came the light. Our operator found out about "Regulex" — the sensitive control which is so fast-acting that it permits reduction of blooming mill reversing time by as much as 40%, yet never allows motor current to exceed safe limits!

Today, that steel man is making every second of blooming mill operation pay its way in mill output. And by eliminating time-wasteful safety margins, he has furthered his reputation for being a "shrewd operator."

MORAL: Maybe "Regulex" control can handle *your* problem of bossing around motors and generators . . . safeguarding their operation, and yet allowing maximum performance.

If the problem involves the control of tension, torque, speed, current —any electrically measurable quantity— "Regulex" control can do the job accurately and quickly. "Regulex" control systems involve no contactors, no trick circuits. The machines themselves are simple and rugged.

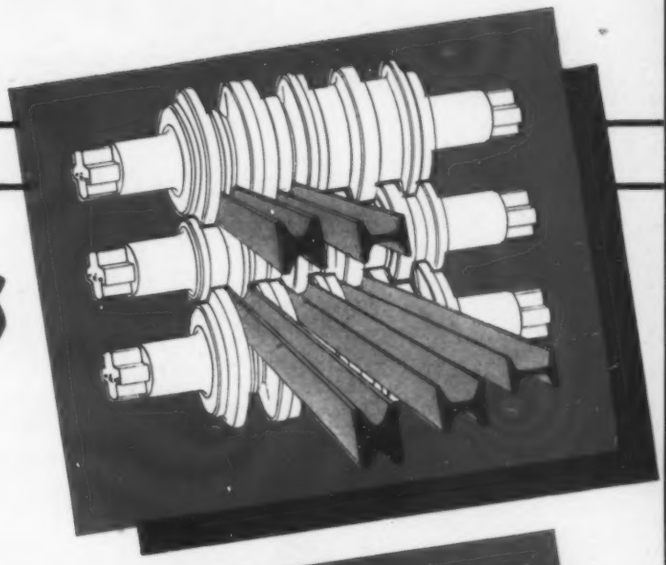
For the full story on "Regulex" control, see our nearby sales office, or write ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN. A 2027

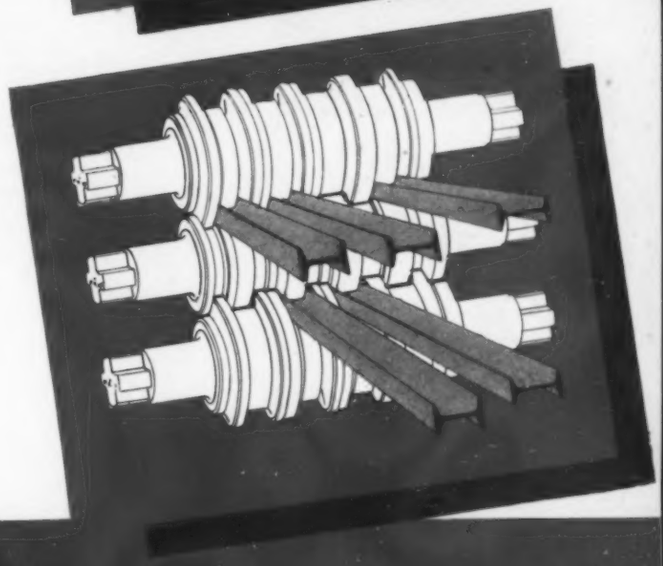


ALLIS CHALMERS **REGULEX CONTROL** *"The Educated Generator"*

ROLLING TECHNIQUE ...

Standard Beams



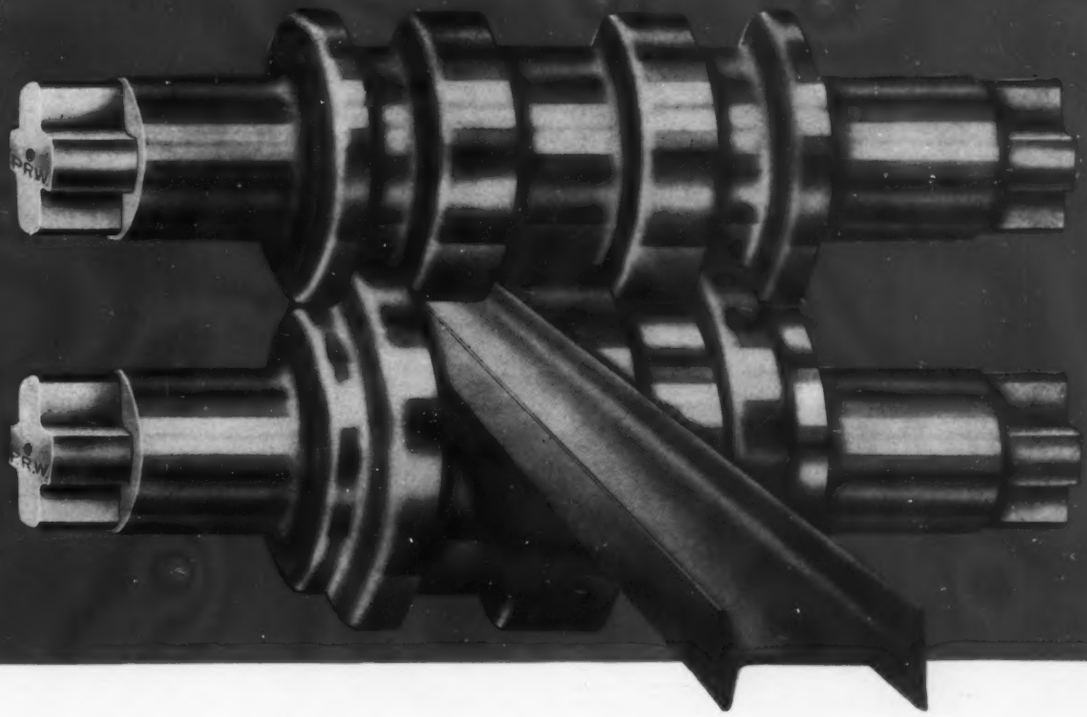


If it is the steel structure for a sky scraper, a warehouse, or a bridge, beams will furnish the main support. Whether it is a 3″ Beam or a 24″ Beam it will require deep passes cut into the rolls to form the flanges. Rolls with high tensile strength and resistance to side wear are required when rolling sections of this type.

Pittsburgh Rolls are made by skilled craftsmen whose thorough practical knowledge of metallurgy, foundry methods and accuracy in roll turning is the accumulated result of more than seventy-five years devoted to the exclusive manufacture of rolling mill rolls. The use of Pittsburgh Rolls can result only in *less cost per ton of steel rolled.*

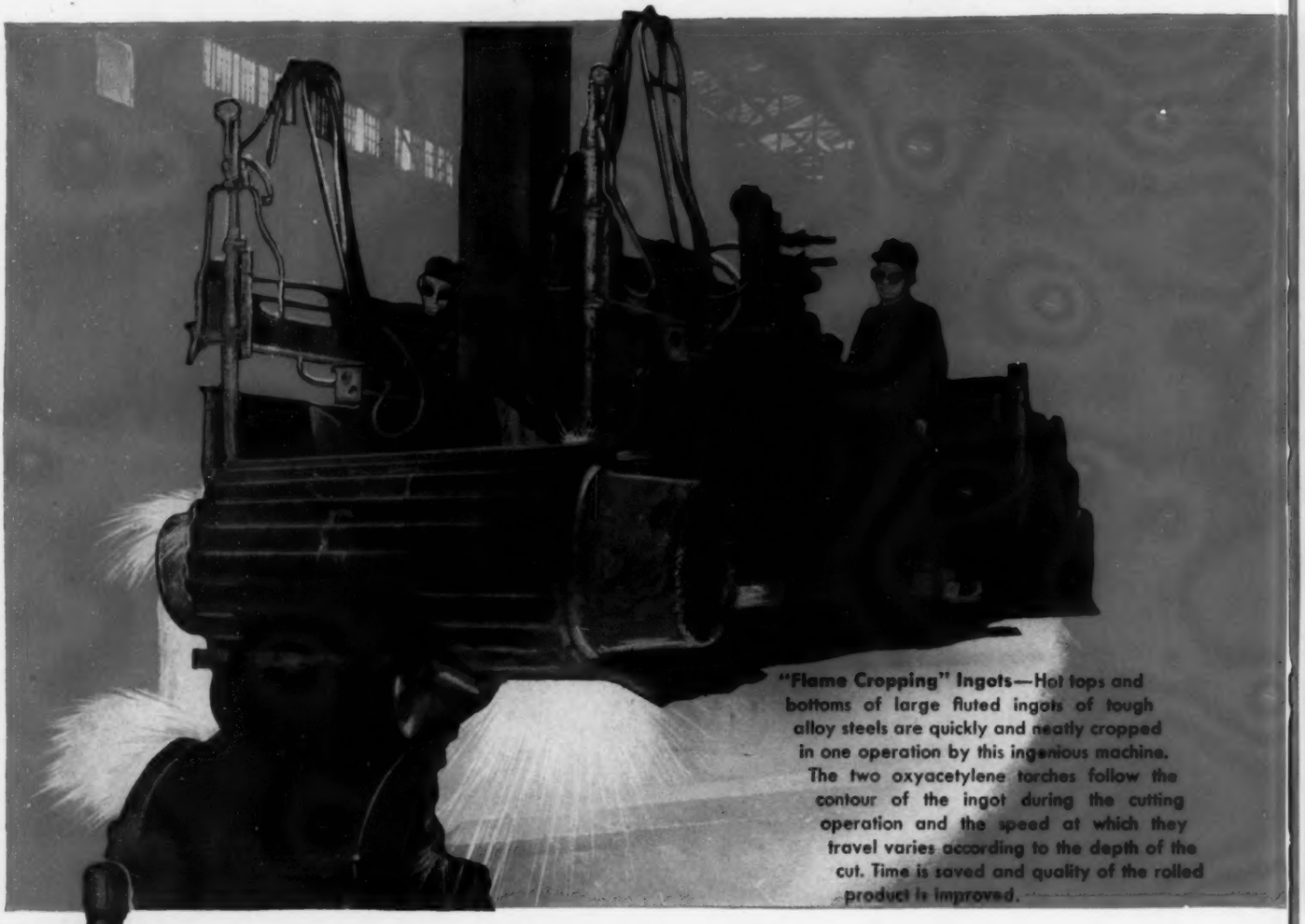
PITTSBURGH ROLLS
Division of Blaw-Knox Company
PITTSBURGH, PA.

PITTSBURGH ROLLS 76 YEARS EXPERIENCE 1870 1946



PITTSBURGH ROLLS

Airco Processes Help "Steel"



"Flame Cropping" Ingots—Hot tops and bottoms of large fluted ingots of tough alloy steels are quickly and neatly cropped in one operation by this ingenious machine. The two oxyacetylene torches follow the contour of the ingot during the cutting operation and the speed at which they travel varies according to the depth of the cut. Time is saved and quality of the rolled product is improved.

IN satisfying the 90-million-ingot-ton appetite of modern mechanized war, America's steel industry found able allies in oxyacetylene flame and electric arc methods developed by Airco. From ore ranges to shipping docks, these versatile processes helped the mills to keep overworked equipment running smoothly, boost tonnage figures and meet the quality standards demanded by the armed forces of the United Nations.

An interesting free booklet: "Oxygen — Indispensable Servant of Industry," is available. Send for your copy.

15

AIR REDUCTION
60 EAST 42nd STREET
NEW YORK 17, N. Y.

Please send me the following material:

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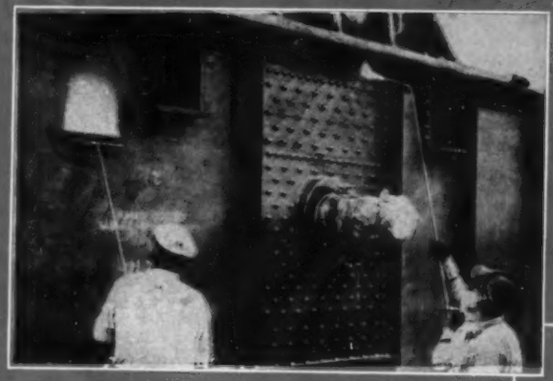
Meet Production Demands . . .

Maintenance Welding — From ladles to laboratory equipment, oxyacetylene and electric arc welding help to keep the vital tools of steel production on the job. Quick repairs by welding save time and eliminate costly shutdowns.

Welding Pipe—Welding with either the oxyacetylene torch or the electric arc, has largely replaced threaded couplings and fittings in steam, water, gas, fuel and air lines in and around mills. Construction time is reduced and the lines withstand severest kinds of service without danger of leakage.



Flame Cleaning and Dehydrating of Structurals — Using special tips, the oxyacetylene flame drives out moisture and removes dirt, grease and loose scale from new steel surfaces, providing a better base for the protective paint coat. Flame cleaning old structures with the same equipment before repainting removes old paint, loose scale and rust and drives out entrapped moisture, assuring longer life for the repaint job. For further information send for bulletins ADG 1066 and 1067.

Plate Edge Preparation for Welding — Small, light-weight Airco Radiagraphs cut straight lines, circles and arcs in steel plate and prepare the edges for welding with straight butt edge, "V" groove, single or double "U" groove, single or double "J" groove or double bevel groove without land. For further information send for bulletins ADC 614 and 627.

OTHER AIRCO PROCESSES TO AID STEEL PRODUCTION

FLAME SCARFING AND DESEAMING
OXYGEN LANCING
SCRAP CUTTING
MACHINE GAS CUTTING
BRONZE WELDING
HARDFACING
CONTROLLED ATMOSPHERES

AIR REDUCTION

AIRCO

General Offices • 60 East 42nd Street, New York 17, N. Y.
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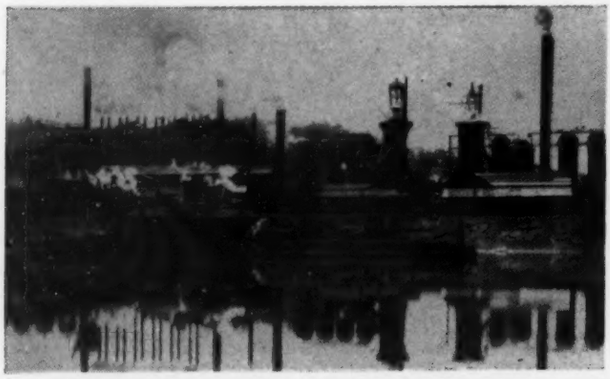
Offices in All Principal Cities
Represented Internationally By Airco Export Corporation

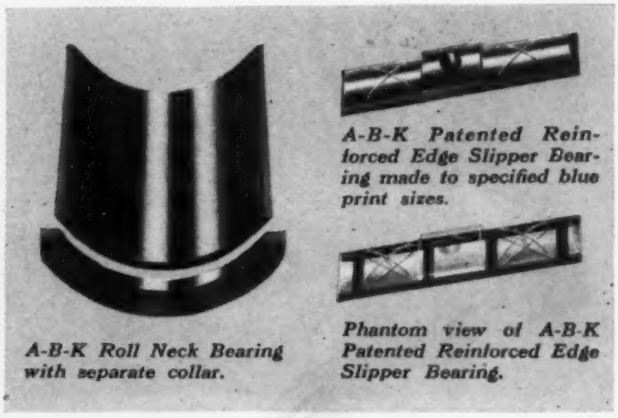
Why are steel mills switching to LAMINATED PLASTIC BEARINGS?*



1. Here's why steel mills are switching to Laminated Plastic Bearings. Records kept by many mills show laminated plastic bearings impressively superior to metal bearings. Investigate these important reasons that stand behind the trend to laminated plastic bearings. One prime consideration is that . . .

2. Laminated Plastic Bearings outwear metal bearings. These bearings customarily have a trouble-free life many times longer than metal bearings. This means fewer shutdowns for bearing replacements. Close tolerances are held with a minimum of roll adjustments. Lost production hours are substantially reduced. Then, too, . . .

3. Lubrication costs are practically eliminated. Water is used to lubricate and cool laminated plastic bearings—no oil or grease. The hard, smooth surface of these bearings, when water lubricated, has an exceptionally low coefficient of friction which results in remarkable power savings. To be sure of these advantages, . . .



A-B-K Patented Reinforced Edge Slipper Bearing made to specified blue print sizes.

A-B-K Roll Neck Bearing with separate collar.

Phantom view of A-B-K Patented Reinforced Edge Slipper Bearing.

4. It is important to specify A-B-K Laminated Plastic Bearings. American Brakeblok Division, American Brake Shoe Company, has designed and engineered A-B-K Laminated Plastic Bearings to take the severest demands of peak production. In service they have proved their ability to make surprising cuts in operating costs.

5. For full information on A-B-K Laminated Plastic Bearings and their applications to your steel mill bearing problems, communicate with American Brakeblok Division, 4600 Merritt Avenue, Detroit 9, Michigan.

American Brakeblok

TRADE MARK REG. U.S. PAT. OFF.

***A·B·K Laminated Plastic Bearings**

Brake Shoe

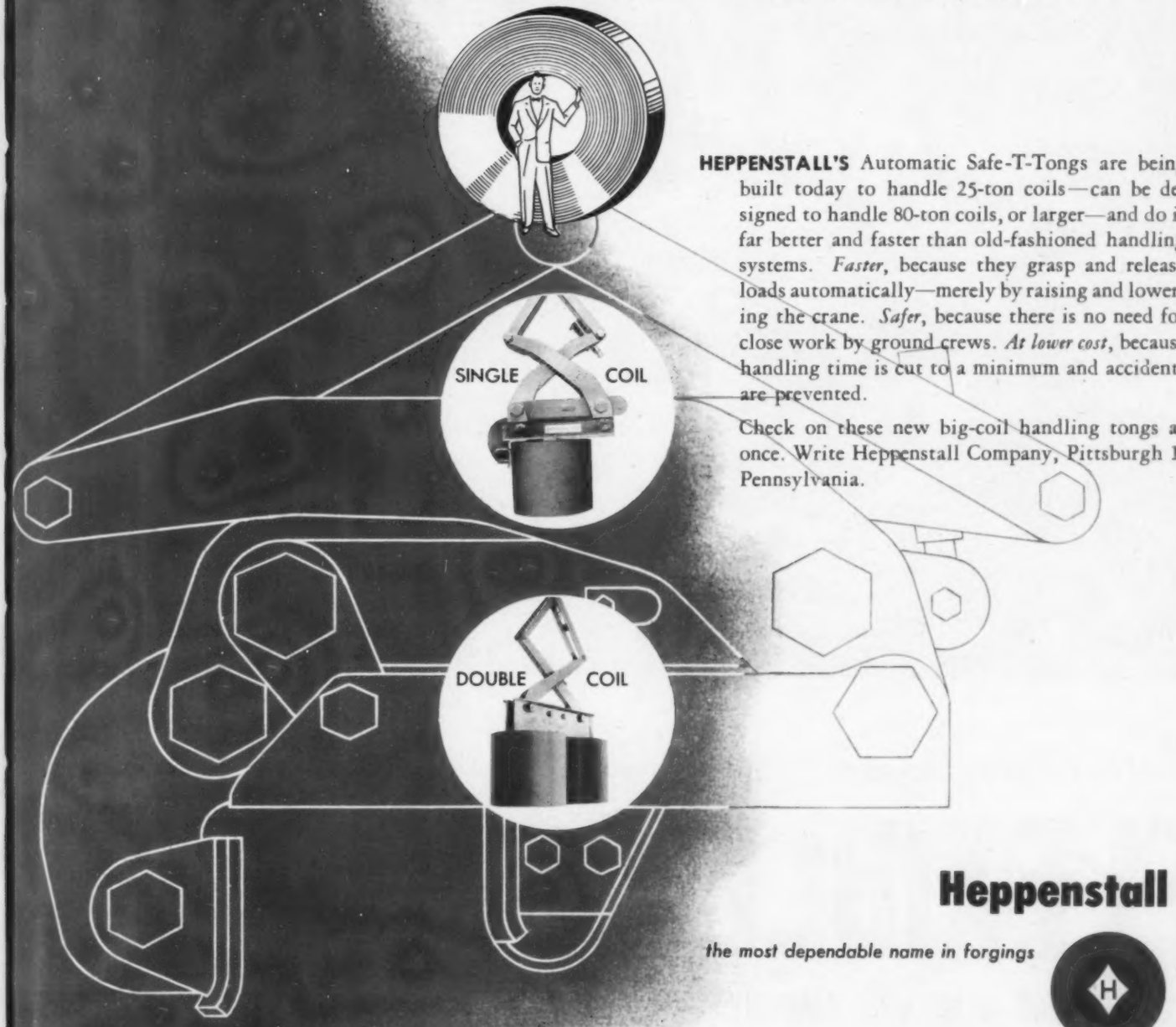
AMERICAN BRAKEBLOK DIVISION • DETROIT 9, MICHIGAN

Are you joining the swing to

Larger coils?

HEPPENSTALL AUTOMATIC SAFE-T-TONGS

will swing them faster and safer, *at lower cost!*



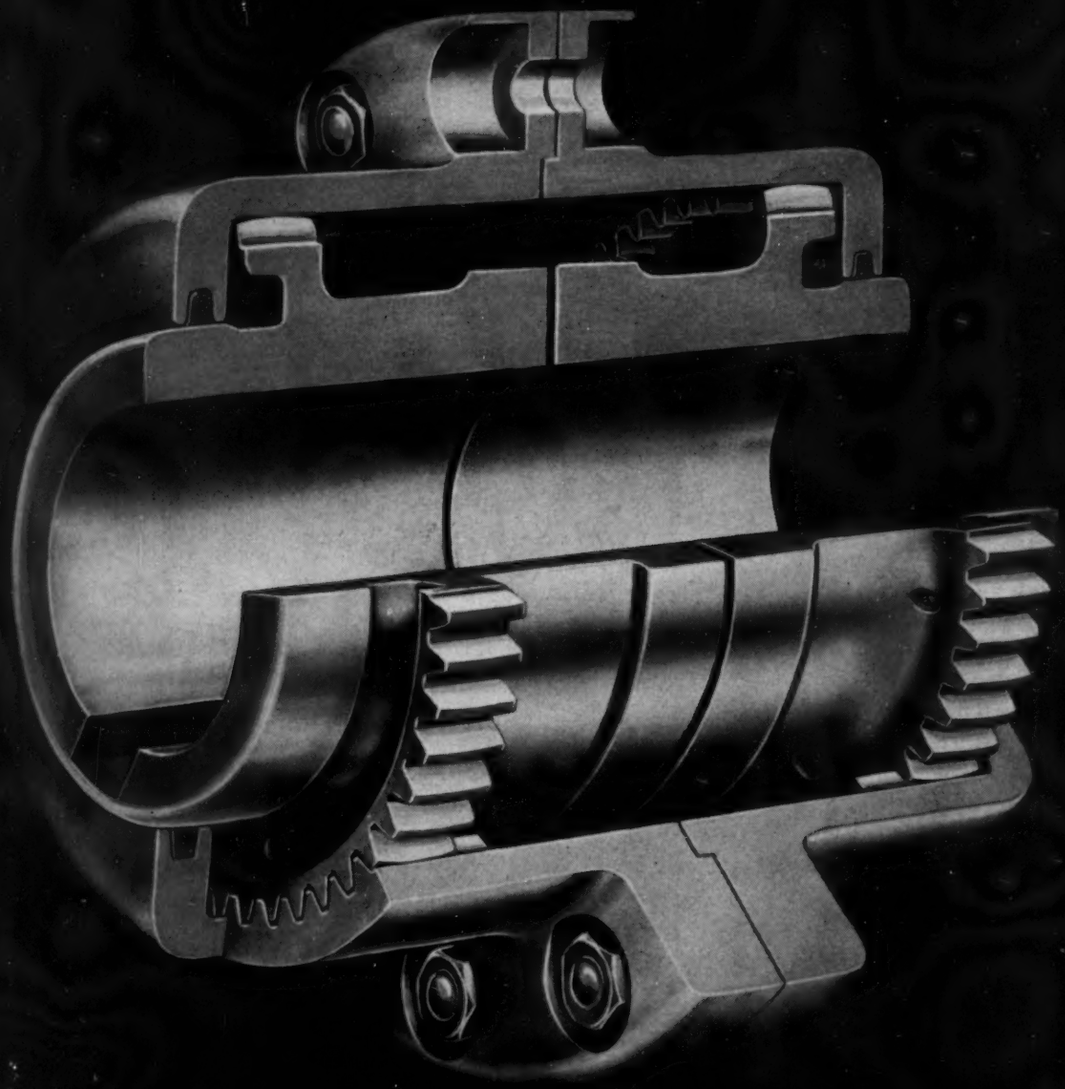
HEPPENSTALL'S Automatic Safe-T-Tongs are being built today to handle 25-ton coils—can be designed to handle 80-ton coils, or larger—and do it far better and faster than old-fashioned handling systems. *Faster*, because they grasp and release loads automatically—merely by raising and lowering the crane. *Safer*, because there is no need for close work by ground crews. *At lower cost*, because handling time is cut to a minimum and accidents are prevented.

Check on these new big-coil handling tongs at once. Write Heppenstall Company, Pittsburgh 1, Pennsylvania.

Heppenstall

the most dependable name in forgings

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

from gas to oil

in an instant

AFTER SIX MONTHS IDLENESS

When a steel plant shares its gas supply with a near-by city, it can expect to be cut off on short notice.

One plant, for example, had only two hours warning during a cold snap last winter—but the shift from gas to oil was made without the slightest interruption of production. Oil firing equipment on the soaking pits went into operation instantly. Hagan Oil Transformers which had been standing idle for six months functioned accurately. No servicing or readjustment was required.

You get performance like this from Hagan Oil Transformers because of the inherent soundness of their engineering. All oil to be measured passes through the Transformer, thus eliminating feeler lines. Viscosity effects are reduced to a minimum by a properly-designed floating orifice. No closely-fitting moving surfaces are involved, hence dirt and grit do not affect accuracy.

Hagan Oil Transformers are available either in new installations or as replacements for other types of oil measuring elements. Our engineers will be glad to give you full information.

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION, HAGAN BLDG., PITTSBURGH 30, PA.

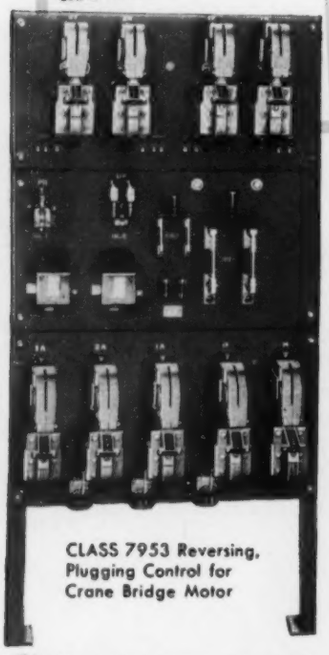
HAGAN Automatic COMBUSTION CONTROL
The pioneer . . . and still the leader
AIR SUPPLY AT CONSTANT PRESSURE
OUTGOING PNEUMATIC LOADING PRESSURE
OIL TO BURNER
FROM OIL SUPPLY
ORIFICE

New Mill-Type MASTER SWITCH

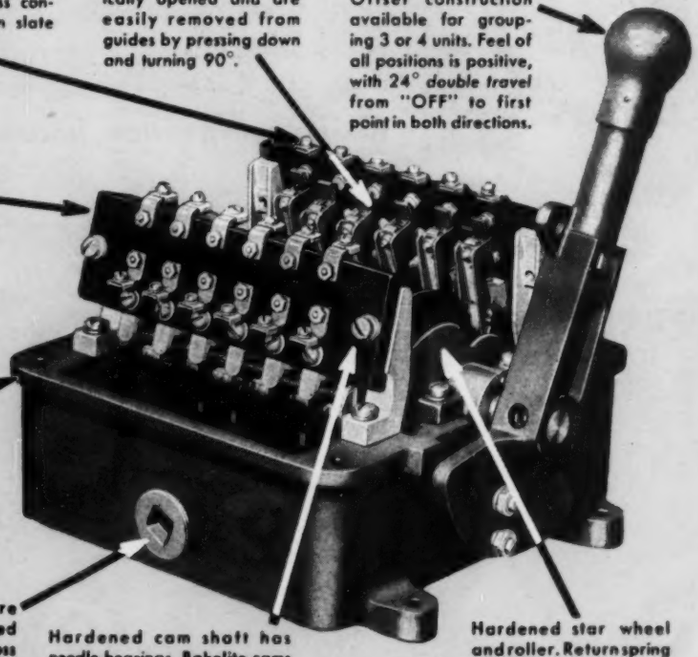
AVAILABLE IN 1 TO 6 POINTS—*Reversing or Non-Reversing*

• Specifications for Square D's new Class 9003, Type AD master switch originated with Mill Engineers. Ordinary construction is not suitable for mill duty where production delays cannot be tolerated and maintenance must be kept at a minimum in spite of severe service. Compare these features with those of other master switches you have used.

Square D also builds the control with which master switches are used . . .



CLASS 7953 Reversing, Plugging Control for Crane Bridge Motor



Stationary contacts with accessible solderless connectors mounted on slate board.

Movable contacts are double-break, silver, spring-closed, mechanically opened and are easily removed from guides by pressing down and turning 90°.

Sturdy handle has "OFF" position latch and padlock feature. Offset construction available for grouping 3 or 4 units. Feel of all positions is positive, with 24° *double travel* from "OFF" to first point in both directions.

Terminal board support serves as *guide* to prevent accidental damage when cover is replaced.

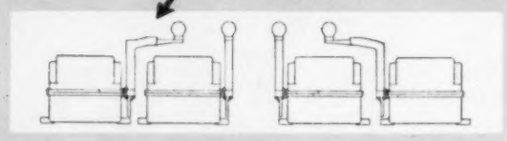
Dust-tight enclosure—split at bearing line for easy maintenance—has shallow box, deep cover and liberal space for internal wiring.

Conduit entrances are 1¼", conveniently located and have sufficient boss for redrilling and tapping to 1½".

Hardened cam shaft has *needle bearings*. Bakelite cams are bolted in position. Complete assembly has unusually wide electrical clearances and can be removed as unit.

Hardened star wheel and roller. Return spring pressure is adjustable.

Straight and offset handles combine to permit grouping of 3 or 4 units with 7" handle centers.

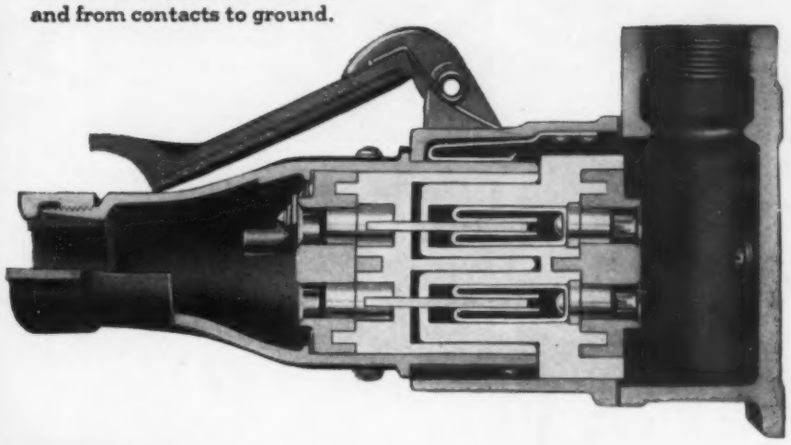


Write for information on CLASS 7950 SERIES Heavy Duty D.C. Control for Cranes and Mill Auxiliaries and CLASS 9003 Type Master Switches. Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin.

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

QuelArc Section; note long distances contact to contact, and from contacts to ground.



QUELARC circuit breaking plugs and receptacles

BUILT FOR MILL SERVICE

The QuelArc line of circuit breaking plugs and receptacles—ratings up to 200 amperes—is built to stand up in mill service, delivering dependable service with minimum maintenance. The exclusive QuelArc construction provides exceptional protection to the contacts, for safe use as current rupturing devices with heavy duty portable electrical equipment.

In the QuelArc design, note the complete enclosure of all contacts in insulating chambers, which form an arc-trapping space. Note also the long distances from contact to contact and from contacts to ground. Contacts are individually renewable and full ground protection is provided.

QuelArc plugs and receptacles are available in a complete line, 2, 3, 4 wire types; ratings 20, 30, 60, 100 and 200 amperes. Many other types of Pyle-National plugs and receptacles are available for portable tools, control and instrument circuits. Consult your Pylet catalog for complete listings.

PYLE-NATIONAL
RAILWAY ELECTRICAL EQUIPMENT
• SINCE 1897 •

THE PYLE-NATIONAL COMPANY

1334-58 North Kostner Avenue - Chicago 51, Illinois

Offices: New York • Baltimore • Pittsburgh • St. Louis
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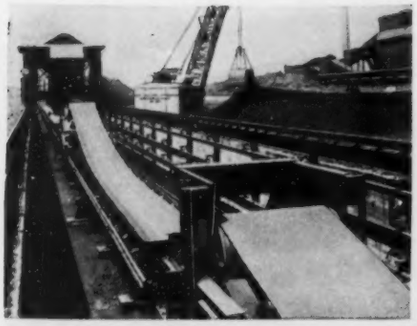
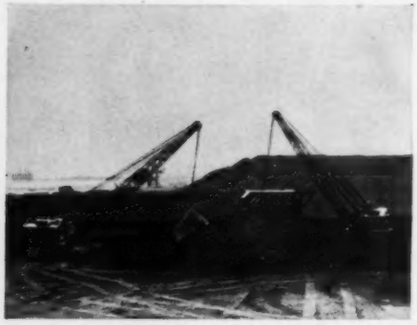
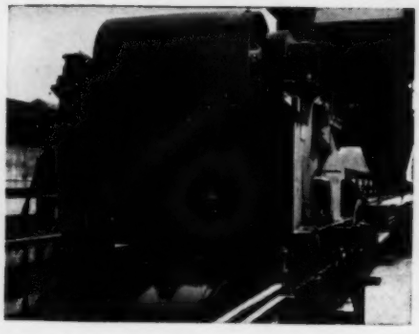
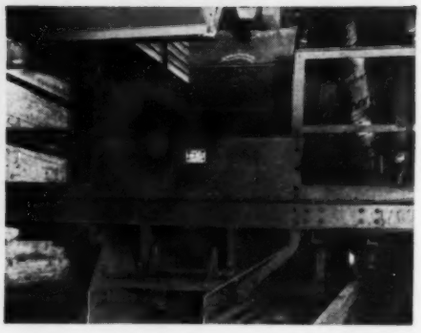
HEADLIGHTS • TURBO-GENERATORS • CONDUIT FITTINGS • FLOODLIGHTS • MULTI-VENT





Lowest-Cost dock operation in America Handles 250,000 Tons of Coal, in and out of storage, a month





• These are views of the Link-Belt Coal Handling Equipment at Great Lakes Steel Corporation, Zug Island near Detroit. This operation has been selected by the U. S. Bureau of Mines as one of the most outstanding coal dock installations in America. It includes handling coal from self-unloading lake vessels into a 7000-ton storage bin out of which the coal is fed uniformly to belt conveyors operating at yard level. Revolving stacker-type belt conveyors deliver the coal to the storage pile, tractor-type bulldozers and crawler cranes impact the stored coal and reclaim it for use at the by-product coke ovens. It is believed that, on a cost-per-ton handling basis, this is one of the most economical dock operations in the country.

1 One of 3 Link-Belt K-480 Speed-O-Matic Diesel Cranes with 3 ton bucket on 60′ boom.

2 180° revolving travelling stacker machine. Delivers coal to storage at rate of 600 tons per hour.

3 Two of 3 Link-Belt K-480 Speed-O-Matic Diesel Cranes reclaiming coal from storage to travelling hopper.

4 Rear view of Link-Belt stacker and tail boom conveyor.

5 Reclaiming hopper showing feeder with loading chute lowered in loading position.

6 Reversible belt conveyor with tripper moved to rear so that reclaimed coal can be directed on to conveyor.

7 Travelling reciprocating feeder in tunnel under 7000 ton storage bin.

8 View of stacker and yard belt conveyor.

9 Tripper moved to end of conveyor. Note the anti-friction self-aligning shaft bearing and self-aligning troughing idler.

10,319

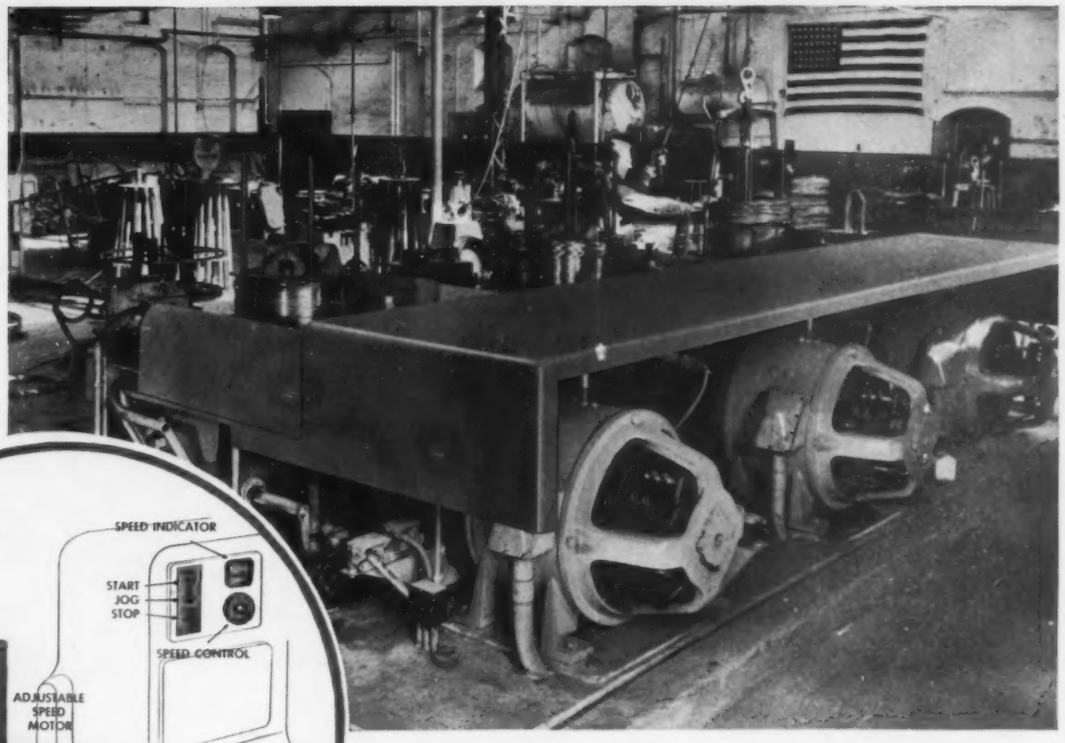
LINK-BELT COMPANY

Chicago 9, Philadelphia 40, Pittsburgh 19, Wilkes-Barre, Huntington 6, W. Va., Denver 2, Kansas City 6, Mo., Cleveland 13, Indianapolis 6.

LINK-BELT CONVEYORS

PREPARATION EQUIPMENT . . . POWER TRANSMISSION MACHINERY

SPOT CONVERSION



Conveniently-packaged, space-saving V★S Drives are available in either Rotating or Electronic Systems or a combination of both systems.

RELIANCE V★S DRIVE SAVES MONEY *by spot conversion of A-c. Power for Adjustable-Speeds*

V★S, the *All-electric, Adjustable-speed Drive operating from A-c. Circuits,* saves money in every plant it enters. Through spot conversion of A-c. power to provide adjustable-speed, it supplies an unlimited range of stepless speed changes. And does it without the expense of alterations in the plant power layout!

Other V★S features, such as starting, stopping and reversing by automatic or manual control from nearby or remote stations, plus the ability to maintain proper tension, are also helping to step up quantity and quality of production, while bringing costs down. Write today for Bulletin 311—the money-saving story of V★S Drive.

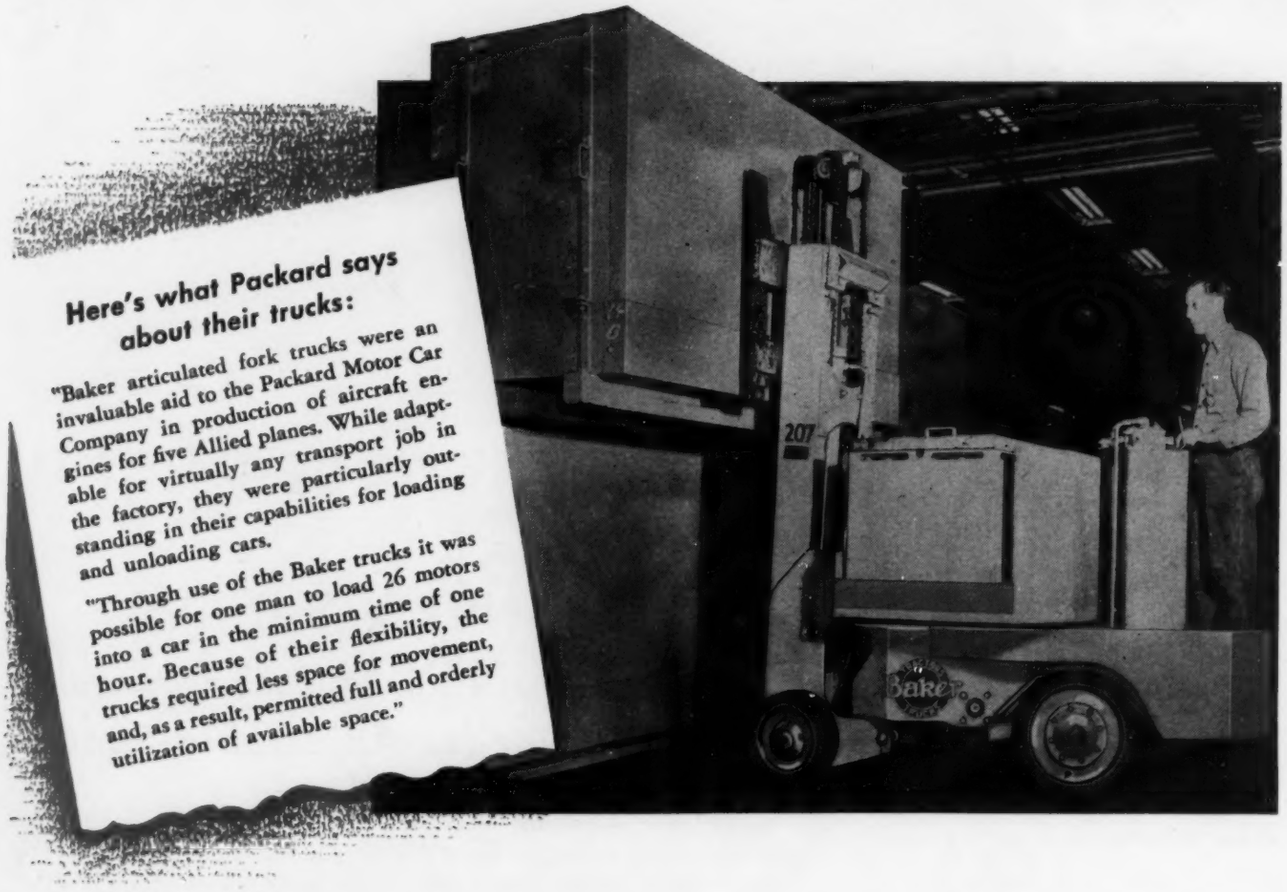
RELIANCE V★S DRIVE

RELIANCE ELECTRIC & ENGINEERING CO.
1084 Ivanhoe Road • Cleveland 10, Ohio

Birmingham • Boston • Buffalo • Chicago • Cincinnati • Denver • Detroit • Gary • Greenville • Houston
Kalamazoo • Kansas City • Knoxville • Los Angeles • Milwaukee • Minneapolis • New Orleans
New York • Philadelphia • Pittsburgh • Portland, Ore. • Rockford, Ill. • St. Louis • San Francisco
Seattle • Syracuse • Tampa • Tulsa • Washington, D. C.

RELIANCE A-C D-C MOTORS *"Motor-Drive is More Than Power"*

"BAKER *Articulated* FORK TRUCKS were an invaluable aid in production of aircraft engines" *Packard Motor Car Co.*



Here's what Packard says about their trucks:

"Baker articulated fork trucks were an invaluable aid to the Packard Motor Car Company in production of aircraft engines for five Allied planes. While adaptable for virtually any transport job in the factory, they were particularly outstanding in their capabilities for loading and unloading cars.

"Through use of the Baker trucks it was possible for one man to load 26 motors into a car in the minimum time of one hour. Because of their flexibility, the trucks required less space for movement, and, as a result, permitted full and orderly utilization of available space."

Baker Articulated Fork Trucks have been in service at the Packard Motor Car Company since 1941. Before that, boxed aircraft engines were loaded into railroad cars with conventional fork trucks. These trucks could load the ends of the car, but to complete the carloading, boxes had to be placed on rollers and pushed into place. This obviously slowed up carloading and required the services of several employees.

Because Baker Articulated Fork Trucks require less clearance for spotting loads and can be easily maneuvered in conjested areas, one operator quickly loaded the complete car without resorting to hand methods. These same advantages also produced similar savings on other material handling operations in production and storage departments.

If you have a problem of moving material where space is limited, or if you would like to use warehouse space to better advantage, let a Baker Material Handling Engineer show you what this revolutionary new truck can do. Or write us direct.

EITA

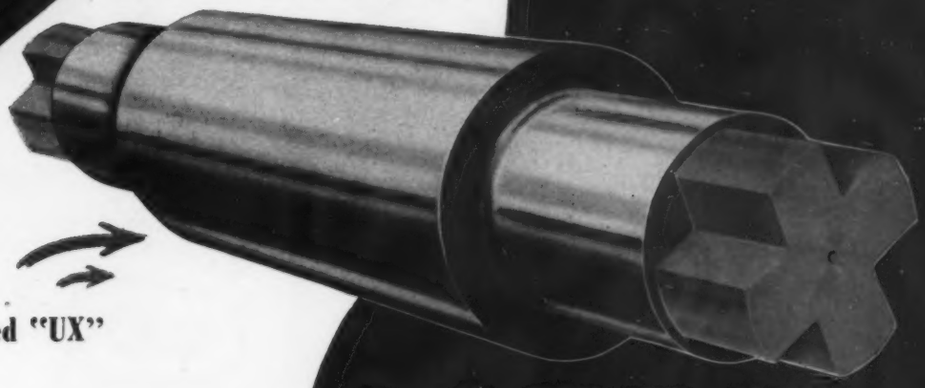
Member:
Electric Industrial Truck Association

BAKER INDUSTRIAL TRUCK DIVISION
of The Baker-Raulang Company
2166 WEST 25TH STREET • CLEVELAND, OHIO
In Canada: Railway and Power Engineering Corporation, Ltd.

UNITED

originators of Color Branded Rolls

(FOR TYPE DESIGNATION)



***United "UX"**

"The Roll with the Yellow Wabbler"

These rolls are made of a low-phosphorous composition to which additional alloys have been added to produce a higher degree of hardness and other desirable physical properties.

Many users find them exceptionally valuable as work rolls in plate mills and 4-high hot strip mills, where they have unfailingly yielded increased tonnages. They have proved useful also for certain sectional rolling.

Greater depth of hardening accounts for their capability to produce better surfaces throughout long periods of operation under the most exacting conditions.

UNITED "UX" ROLLS are supplied in three grades:

Mild . . . 45-60 Shore
Medium . . . 60-68 Shore
Hard . . . 68-72 Shore

The assistance of our roll engineers is available in studying critically, any intended application.

One of a Complete Line of 15 UNITED ROLLS Individually Color-Branded for Type Designation

The 15 principal classifications comprising the UNITED ROLL LINE . . . each one a roll type successfully used in modern industry . . . are individually and distinctively *color-branded* to designate *type, composition* and *service application.* Roll selection is thereby made easy and accurate.

UNITED ROLLS are the product of advanced metallurgical research and more than 40 years experience in roll design and manufacture.

UNITED ENGINEERING AND FOUNDRY COMPANY

Pittsburgh, Pa.

Plants at Pittsburgh · Vandergrift · New Castle · Youngstown · Canton
Subsidiary: Adamson United Company, Akron, Ohio
Affiliates: Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal, P.Q. Canada

The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment

LOOK TO THE FUSE LEADER FOR PRODUCTION PROGRESS

WARE HI-LAG *Renewable* FUSES

THE FUSE THAT PREVENTS EXCESSIVE HEATING AND NEEDLESS BLOW-OUTS—GIVES 100% PROTECTION

End once and for all times the unnecessary delays—shut downs—interruptions and costly expense resulting from out-of-date fuses.

Modern science has developed the coolest operating fuse in the WARE HI-LAG—the SAFE—ECONOMICAL and FOOL PROOF Fuse, giving greatest satisfaction and service with full protection.

The reasons for WARE HI-LAG Super Performance are—higher lag for starting loads and surges—greater strength and durability—link designed for maintaining low resistance—non-heating, spring tension contacts with greater contact area. These are features which save time, expense and renewal costs. Start economizing! Try WARE HI-LAG Today!

Write for Brochure giving details of all the COOL FACTS, sizes and prices.

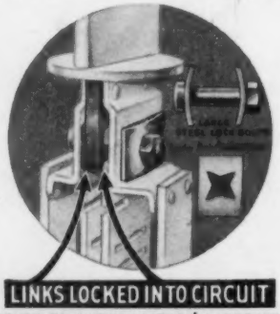
Cool Facts No. 3

NON-HEATING CONTACTS

The wide contact surface maintains low contact resistance.

Spring tension on links locked into position, prevents loosening of contacts, which causes over heating.

Connections held firm by large arched spring steel washers and heavy bolts.



APPROVED BY UNDERWRITERS' LABORATORIES

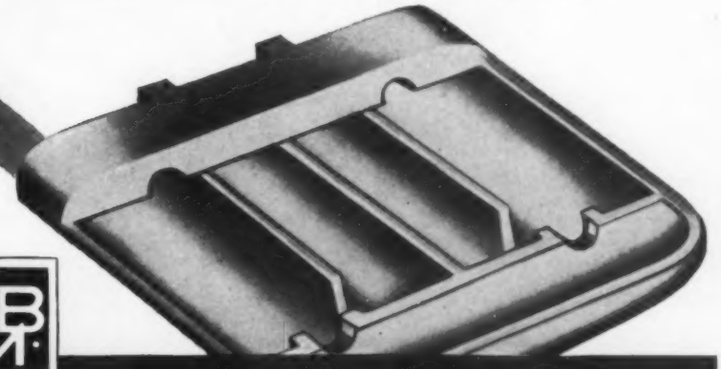
WARE *Brothers* 4450 W. LAKE ST.·· CHICAGO 24, ILL.

NO DANGER
N·B·M
BOSH PLATES AT WORK

NOSE-COOLED N·B·M BOSH PLATES PROTECT YOUR FURNACE LININGS FROM WATER LEAKS

In actual tests, N-B-M double-compartment bosh plates lasted 5 times longer than conventional single-compartment plates. They are far more resistant to fire cracks and damaging leaks because high-velocity cold water is delivered directly to the nose. Other advantages:

- Faster cooling • No sediment accumulation
- If nose should finally crack, the second compartment can be used for cooling
- Furnished complete with pipes, ready to install.



N·B·M
BRONZE AND COPPER CASTINGS

Blast Furnace Copper Castings • Roll Neck Bearings • Slippers • Housing Nuts • Machinery Castings • Babbitt Metals • Acid Resisting Castings • Phosphorized Copper

NBM

NATIONAL BEARING
DIVISION

PITTSBURGH • NEW YORK

AMERICAN Brake Shoe COMPANY

PLANTS IN: ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

● BUILT BY LAKESIDE BRIDGE & STEEL CO.

This

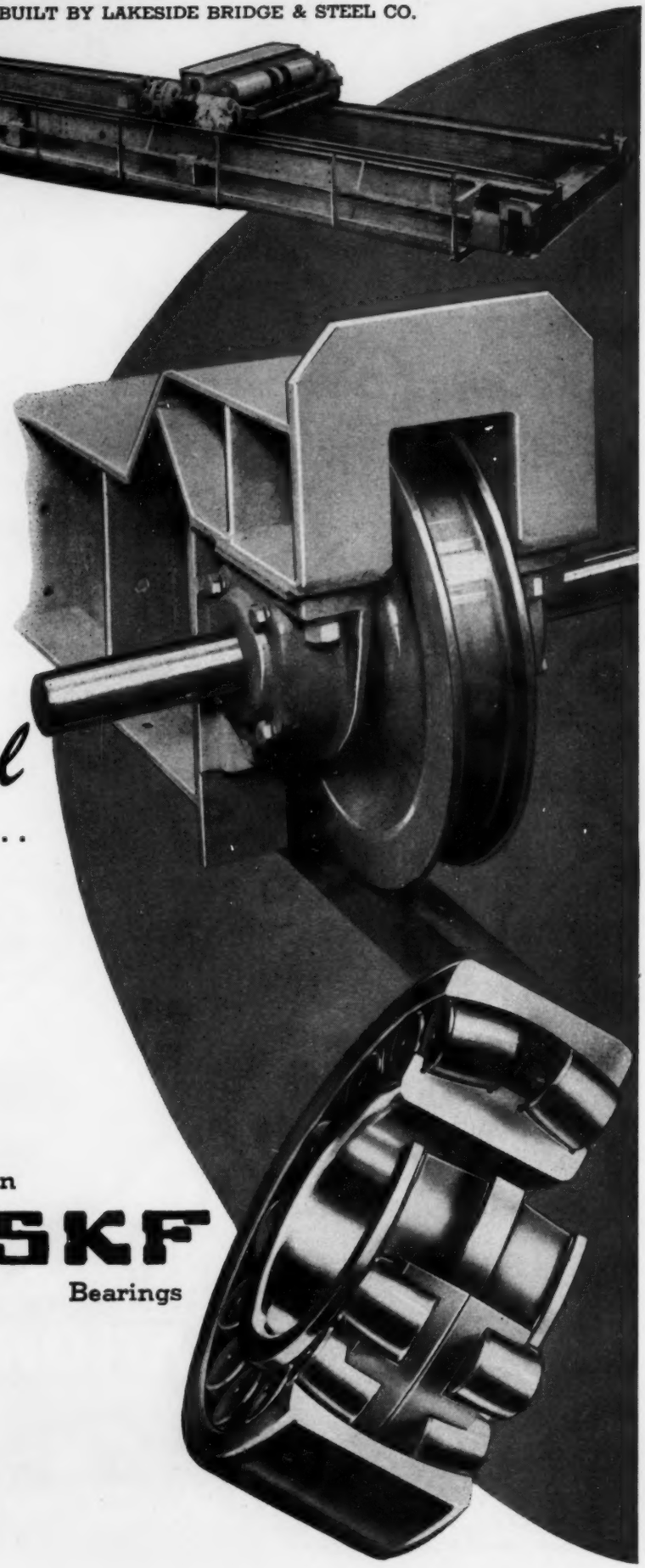
Crane

depends . .

on this

Bridge Wheel

that depends . . .



SKF Spherical Roller Bearings are equally spaced either side of the wheels on the Bridge End Truck of this 10-ton, 97-foot span Lakeside Dynamic Crane. They automatically take care of misalignment due to load deflections of axles and trucks . . . carry all thrust loads. Another outstanding result of SKF's pioneering the self-aligning roller bearing.

on

SKF

Bearings

SKF INDUSTRIES, INC., PHILA. 34, PA.

BILLETEER LABOR SAVINGS REALLY COUNT NOW

Recent wage increases make it necessary to scrutinize operations all down the line to avoid being squeezed between fixed price ceilings and rising costs.

Here is where Billeteer-equipped billet-sheds have the edge on mills which still rely on manual methods of steel conditioning.

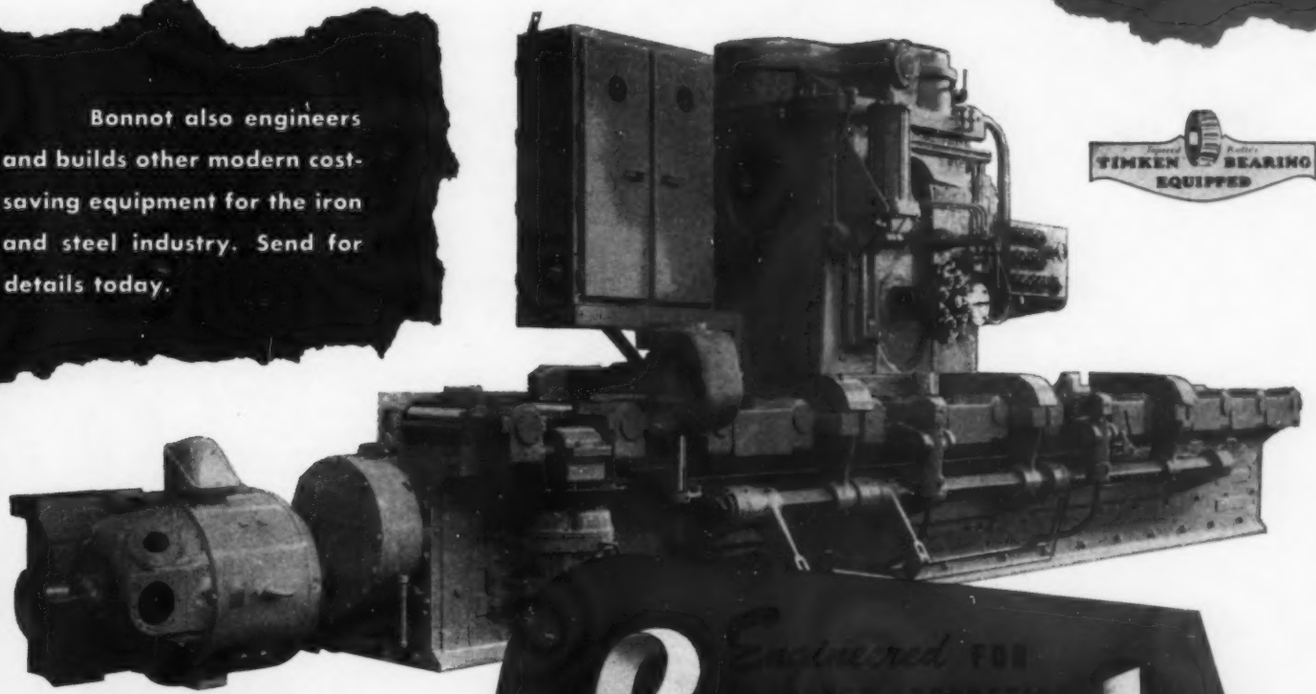
One man operating a Bonnot Billeteer does the work of ten hand chippers, saving $1.66½ (9 × 18½c) an hour *just in wage increases.*

So this is *but a fraction of the total savings* which the Billeteer is making in scores of mills. It never gets tired, groggy or jittery . . . works with unflagging efficiency through shift after shift, doing a neater and better job and releasing good men for less killing tasks.

With a semi-skilled operator, the Bonnot Billeteer easily cleans billets that would be scrapped because of the prohibitive cost of manual chipping. And it enables you to salvage tons of clean, known-analysis chips, ready for immediate resmelting.

Let us show you how the Billeteer can help to cut your steel conditioning costs. Write for the facts and figures.

Bonnot also engineers and builds other modern cost-saving equipment for the iron and steel industry. Send for details today.



CHARGING TABLES • BILLET INSPECTION TABLES • CLAY MIXERS • GRINDING PANS CLAY FEEDERS • COLD SAWS

Engineered for

Bonnot

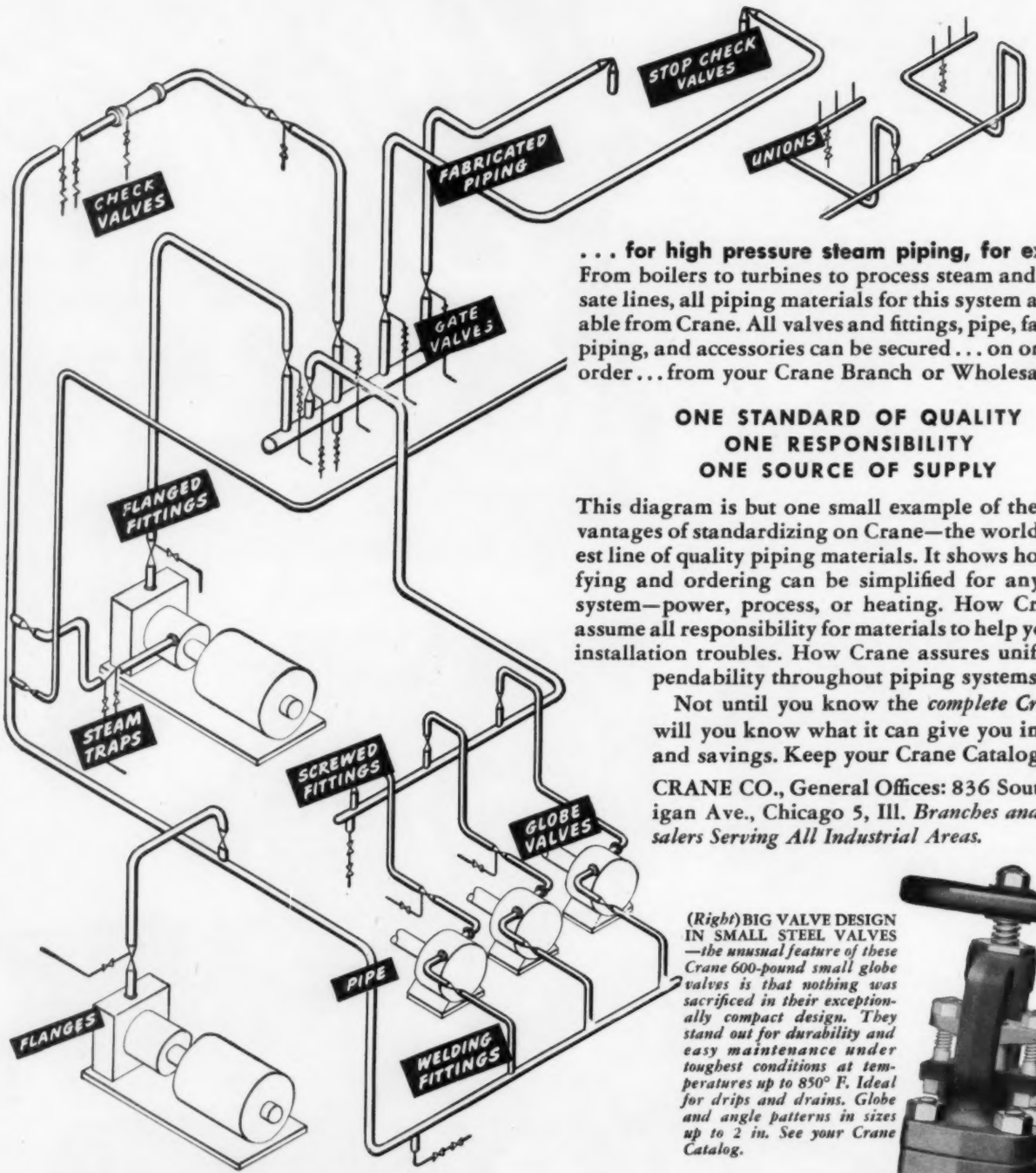
BUILDERS OF **THE BILLETEER**

CANTON 2, OHIO

ADDRESS CORRESPONDENCE TO STEEL EQUIPMENT DIVISION

ONE ORDER TO CRANE . . .

Covers All Piping Materials



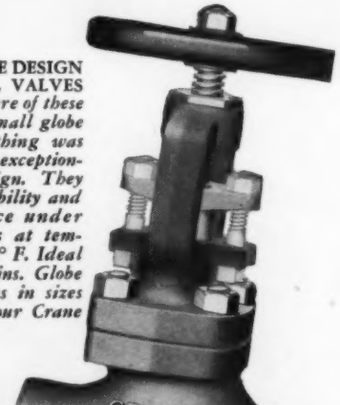
. . . for high pressure steam piping, for example. From boilers to turbines to process steam and condensate lines, all piping materials for this system are available from Crane. All valves and fittings, pipe, fabricated piping, and accessories can be secured . . . on one single order . . . from your Crane Branch or Wholesaler.

ONE STANDARD OF QUALITY
ONE RESPONSIBILITY
ONE SOURCE OF SUPPLY

This diagram is but one small example of the big advantages of standardizing on Crane—the world's greatest line of quality piping materials. It shows how specifying and ordering can be simplified for any piping system—power, process, or heating. How Crane can assume all responsibility for materials to help you avoid installation troubles. How Crane assures uniform dependability throughout piping systems.

Not until you know the *complete Crane line* will you know what it can give you in service and savings. Keep your Crane Catalog handy.

CRANE CO., General Offices: 836 South Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*



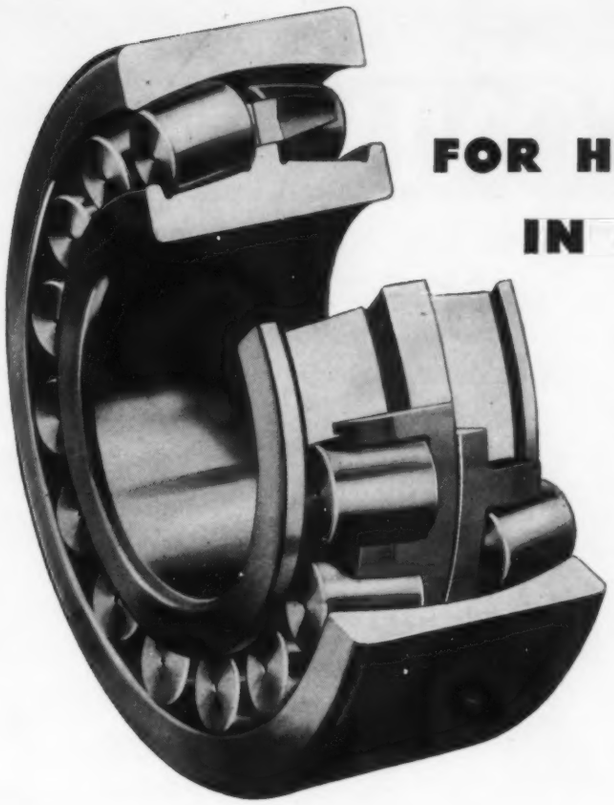
(*Right*) BIG VALVE DESIGN IN SMALL STEEL VALVES —*the unusual feature of these Crane 600-pound small globe valves is that nothing was sacrificed in their exceptionally compact design. They stand out for durability and easy maintenance under toughest conditions at temperatures up to 850° F. Ideal for drips and drains. Globe and angle patterns in sizes up to 2 in. See your Crane Catalog.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
HEATING • PUMPS

CRANE

FOR EVERY PIPING SYSTEM

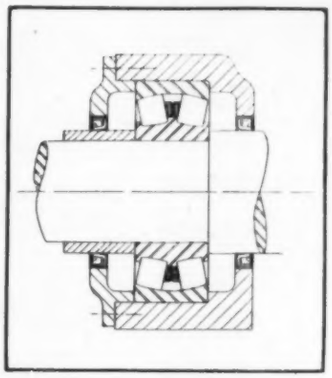


FOR HEAVY-DUTY SERVICE IN MANY INDUSTRIES

In every industry where the efficient operation of heavy-duty machinery is of major importance, difficult friction problems are being solved with the versatile Torrington Self-Aligning Spherical Roller Bearing.

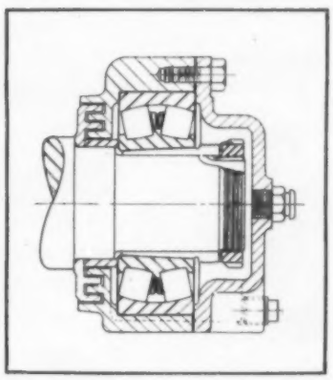
For your specific requirements, the engineering staff of Torrington's Bantam Bearings Division will be glad to offer expert assistance in adapting the Self-Aligning Spherical Roller Bearing to machinery you design, build or operate. For further information, contact your nearest Torrington Representative or write for our Bulletin No. 100A.

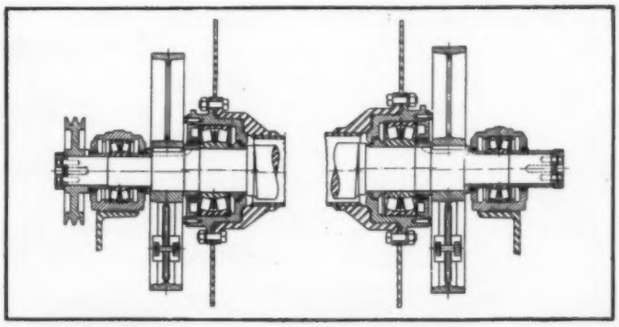
THE TORRINGTON COMPANY
BANTAM BEARINGS DIVISION, SOUTH BEND 21, INDIANA



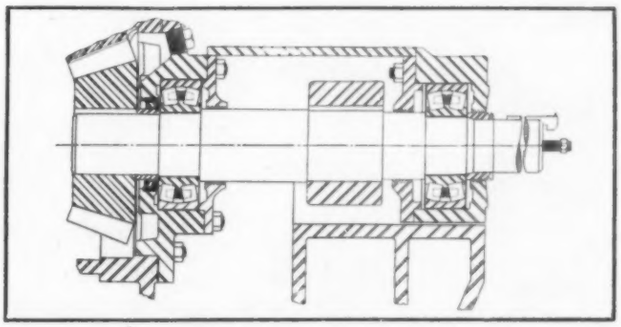
STEEL... X-section drawing shows a typical arrangement for the Torrington Self-Aligning Spherical Roller Bearing in modern, high speed auxiliary equipment for steel mills. Temperature changes, misalignment and high load stresses do not affect the free-rolling action within the bearing. Its greater inherent capacity under variable conditions provides wide adaptability.

PAPER... This X-section shows an application of a taper bore Spherical Roller Bearing to a press roll, where it is mounted on a straight shaft by means of an adapter. Through the use of this tapered sleeve, the internal running clearance is controlled by the amount of expansion given the inner race. Proper roller contact with both races assures full capacity under all conditions.





CONSTRUCTION... This X-section drawing shows a mounting of four Torrington Self-Aligning Spherical Roller Bearings on the main eccentric shaft of a shaker screen. The self-aligning feature of the bearings easily compensates for distortion and satisfactorily handles heavy shock loads.



OIL... Shown in X-section above are two Torrington Self-Aligning Spherical Roller Bearings applied to a pinion shaft as used in oil field rotary table drives. Heavy shock loads and shaft deflections do not affect the efficient free-rolling self-alignment of the bearing in this application.

TORRINGTON BEARINGS

SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL

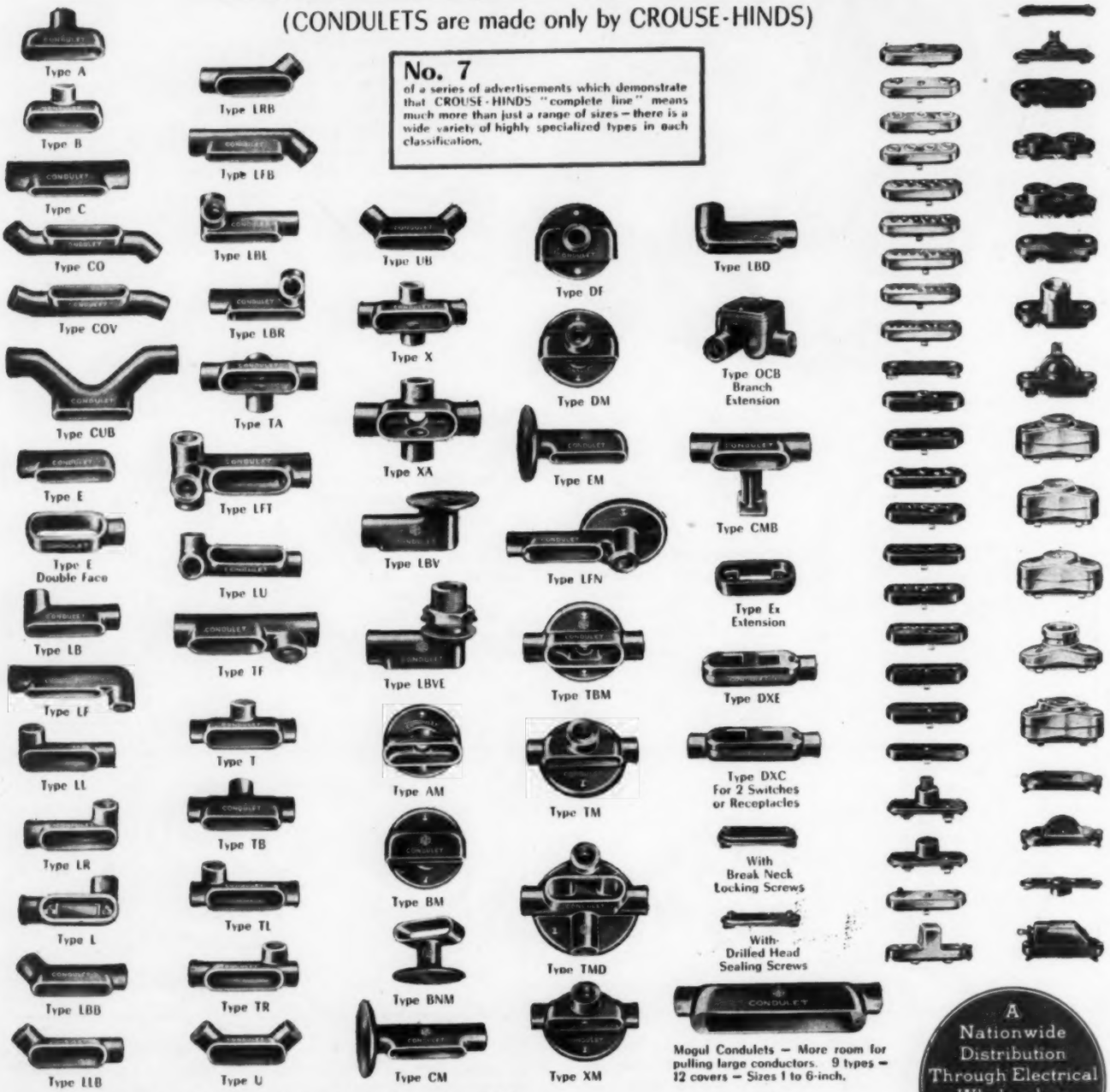
The extensive line of

Obround CONDULETS

simplifies your installation problems.

51 types of bodies — sizes 1/8 to 6-inch — a wide selection of interchangeable covers and wiring devices.

(CONDULETS are made only by CROUSE-HINDS)



No. 7
of a series of advertisements which demonstrate that CROUSE-HINDS "complete line" means much more than just a range of sizes — there is a wide variety of highly specialized types in each classification.

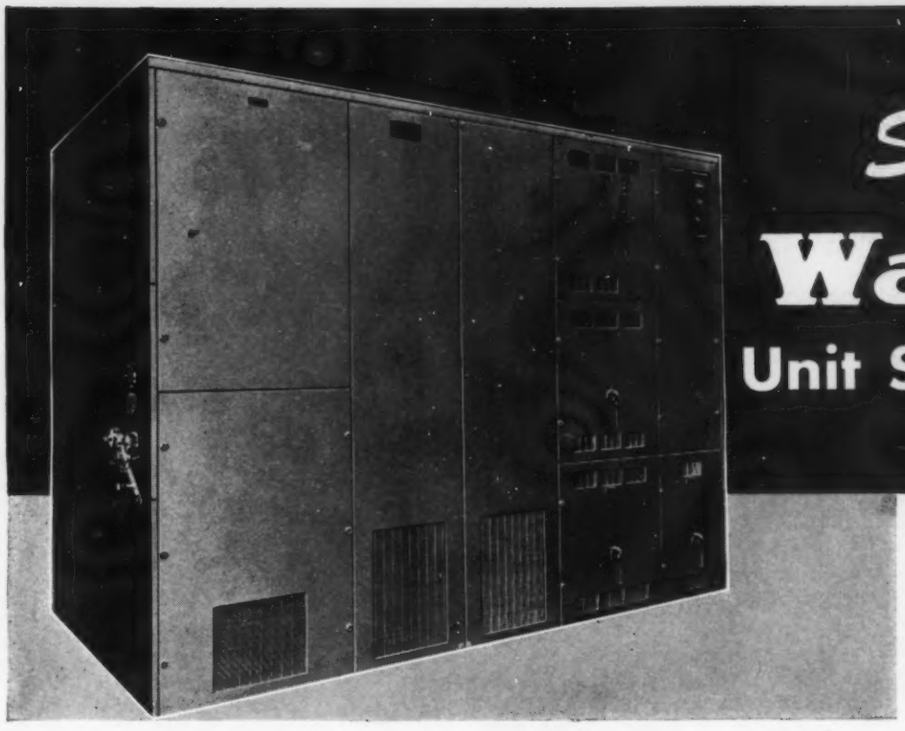
Complete listings of each type are in Condulet Catalog No. 2500

A Nationwide Distribution Through Electrical Wholesalers

CROUSE-HINDS COMPANY
Syracuse 1, N. Y., U.S.A.

Offices: Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland — Dallas — Denver — Detroit — Houston — Kansas City — Los Angeles — Milwaukee — Minneapolis New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington. *Resident Product Engineers:* Albany — Atlanta — Charlotte
CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

CONDULETS · TRAFFIC SIGNALS · AIRPORT LIGHTING · FLOODLIGHTS



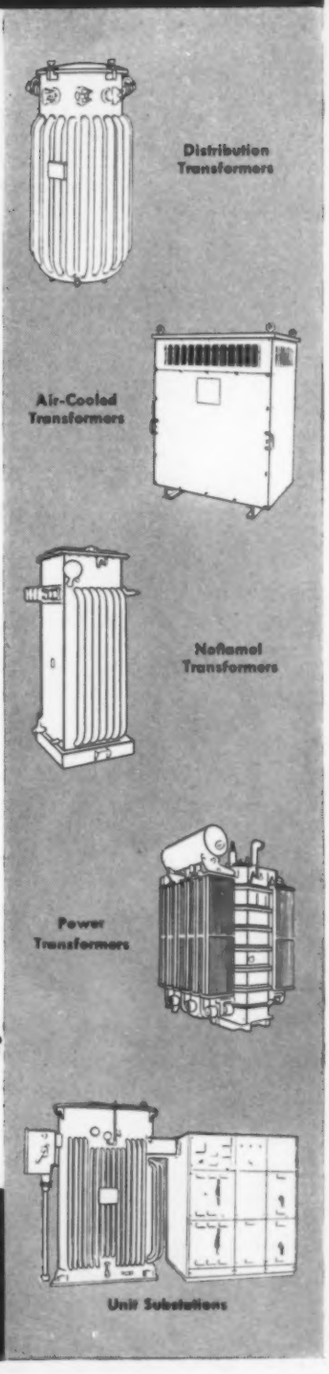
Specify
Wagner
Unit Substations!

One order to Wagner brings everything needed to meet your exact transformer and switchgear needs—a complete unit substation engineered as a single unit, fully backed with undivided responsibility by Wagner.

Wagner unit substations are easy to install—and when future load changes so dictate, easy to move intact to a new location.

In addition to (1) ease of ordering, (2) undivided responsibility, (3) simplicity of installation and (4) ease of relocation, Wagner unit substations offer you such other important advantages as (5) less installation expense, (6) maintenance is simplified, (7) low-voltage feeders are shortened, (8) less manpower needed to make changes, (9) built of the highest-quality materials in accordance with the latest engineering practices.

Get acquainted with entire Wagner line of distribution and power transformers. Ask for Bulletins TU-180 and TU-181, gladly sent on request addressed to Wagner Electric Corporation, 6483 Plymouth Avenue, St. Louis 14, Mo.



Other Wagner Products for Industry: Air Brakes • Brake Lining • Electric Motors • Hydraulic Brakes • Industrial Braking Systems • NoRoL • Tachograph

Consult Wagner Engineers on all Transformer Problems

Wagner

T46-3

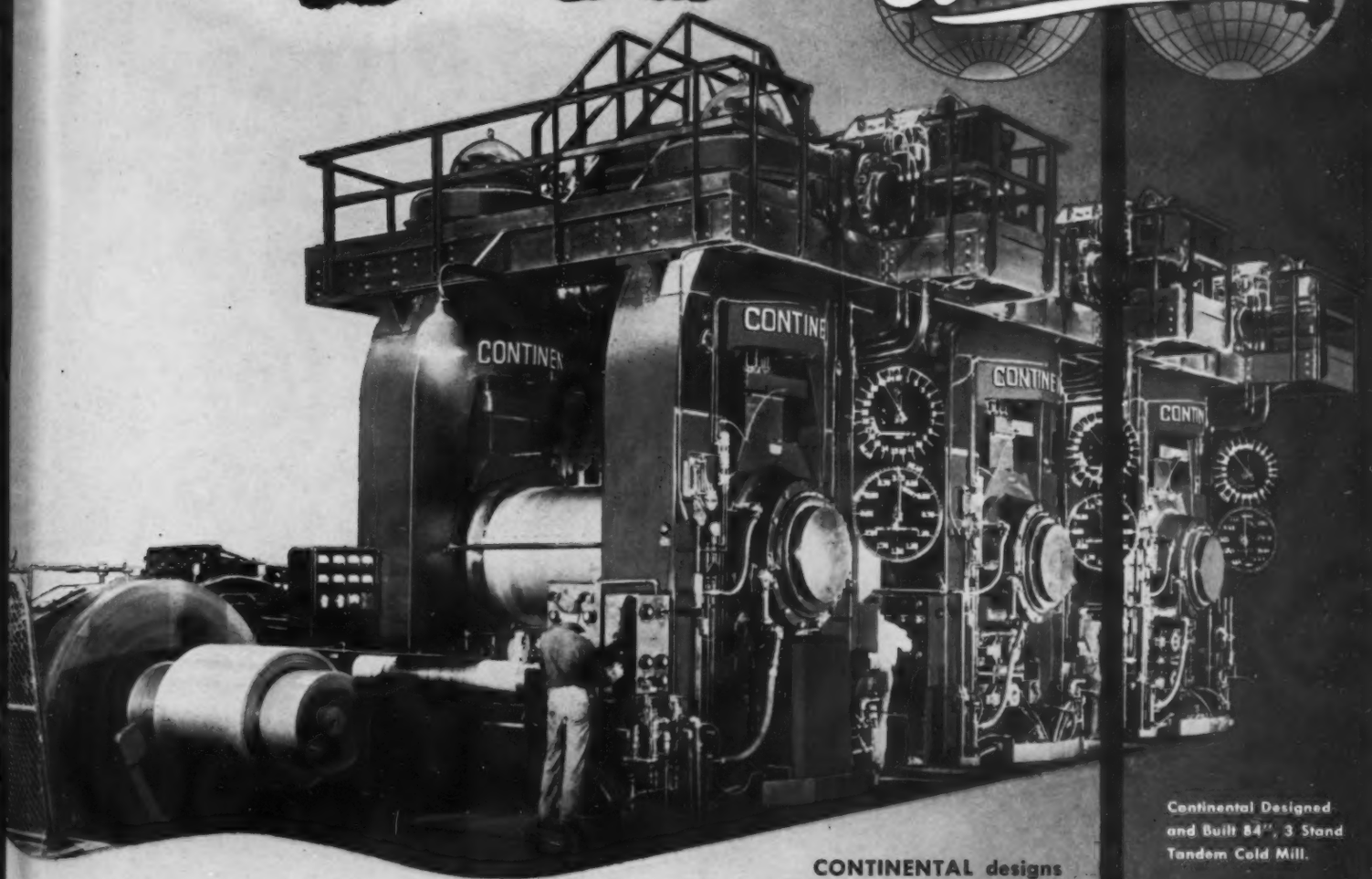
Sales and Service Branches: ATLANTA 3 • BALTIMORE 18 • BOSTON 15 • BUFFALO 8 • CHICAGO 16 CINCINNATI 10 • CLEVELAND 15 • DALLAS 1 • DENVER 2 • DETROIT 2 • HOUSTON 2 • INDIANAPOLIS 4 KANSAS CITY 8 • LOS ANGELES 15 • MEMPHIS 3 • MILWAUKEE 2 • MINNEAPOLIS 4 • NEW YORK 7 OMAHA 2 • PHILADELPHIA 8 • PITTSBURGH 13 • PORTLAND 9 • ST. LOUIS 3 • SALT LAKE CITY 1 SAN FRANCISCO 3 • SEATTLE 4 • SYRACUSE 2 • TULSA 3 • WASHINGTON 5
In Canada: WAGNER ELECTRIC AT LEASIDE, ONTARIO

For high finish at high speed it will pay you to equip your cold mills with Lewis Finishing Rolls, with necks ground to suit your bearings. They help you maintain production and keep your tonnage costs low.
LEWIS ROLLS
ARMY
NAVY
MANUFACTURERS OF ROLLS AND ROLLING MILL MACHINERY FOR THE IRON, STEEL AND NON-FERROUS INDUSTRIES
LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX COMPANY
PITTSBURGH, PA.

Continental

WORLD HEADQUARTERS for Rolling Mill Equipment

Continental



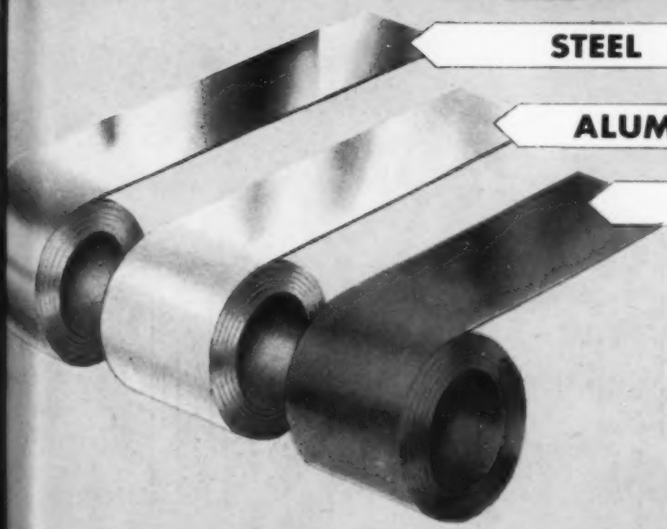
Continental Designed and Built 84", 3 Stand Tandem Cold Mill.

CONTINENTAL designs and builds new engineering ideas in metal producing and handling machinery and equipment...

STEEL

ALUMINUM

BRASS



Whether it be a set of rolls or a complete producing plant—for any ferrous or non-ferrous metal—bring your equipment problems to CONTINENTAL!

Continental

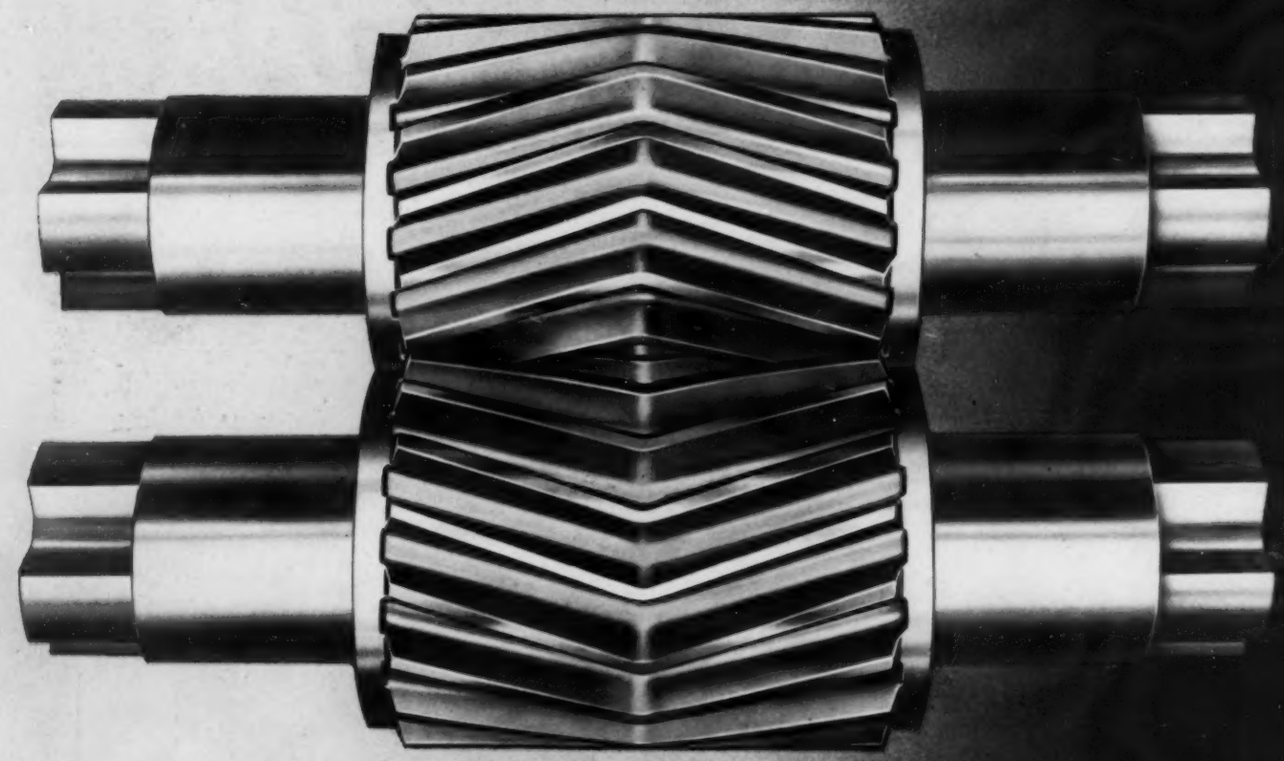
FOUNDRY & MACHINE CO.

PITTSBURGH • CHICAGO

Plants at East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.

4 modern Continental Plants

Specializing in the building of your Iron Rolls • Steel Rolls



Cost-conscious mill operators, everywhere, insist upon CONTINENTAL Rolls and Pinions —they stand up through difficult, high-speed production, are dependable in service, and provide greater tonnage, which makes for minimum rolling costs.

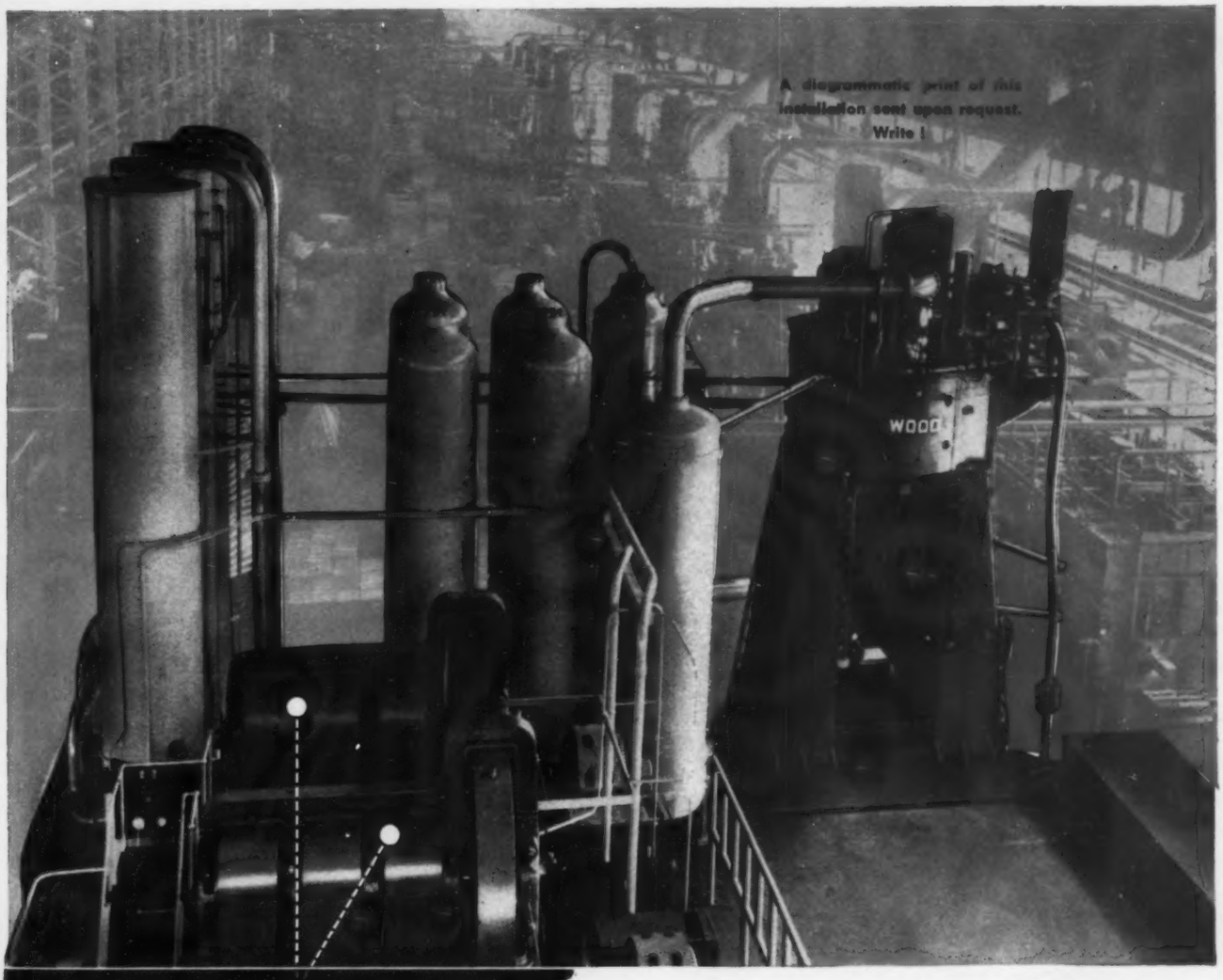
Master craftsmanship, advanced engineering, thorough knowledge and experience in Rolling Mill problems, plus the vast resources of four modern plants are your assurance that CONTINENTAL Rolls and Pinions are Best for Service.

Continental

FOUNDRY & MACHINE CO.

PITTSBURGH • CHICAGO

Plants at East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.



These 2 Pumps do the work of 20!

. . . with this ACCUMULATOR System

Because accumulator systems permit storing hydraulic power during idle portions of the press cycle, industry is turning more and more to such installations for obvious economies. Since smaller or fewer pumps can be used—initial pump costs are minimized and operating power consumption is usually reduced. For example, shown here is an air-bottle accumulator system and two 300-hp pumps which readily handle the operation of this 3,000-ton Wood high-speed hydraulic forging press. Without the accumulator system 20 pumps of like capacity would be required to do the job.

As manufacturers of hydraulic presses and equipment for more than a half century, we have designed and built systems for high and low pressure delivery, with accumulators of weight-loaded, air-bottle and hydro-pneumatic types. On the other hand, we are equally as well experienced with direct pumping units of all types. Remember, Wood accumulators minimize line shock, provide for a more even and constant pressure in the system and insure longer life of pipes, valves, controls, packing, dies and molds. Regardless of the size or service of the presses you operate, whether it be 1 or a hundred, let R. D. Wood engineers recommend the type of cost-cutting hydraulic equipment to best fill your needs.

Write us today! R. D. Wood Company, Public Ledger Building, Independence Square, Philadelphia 5, Pa.

HYDRAULIC PRESSES AND VALVES FOR EVERY PURPOSE • INTENSIFIERS ACCUMULATORS • ALLEVIATORS

R. D. WOOD COMPANY

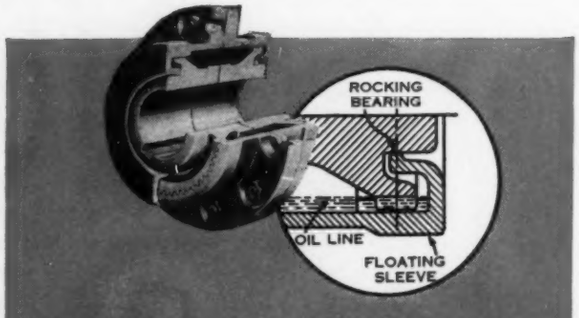
EST. 1803

23 YEARS ON A PUNISHING JOB WITH NO DELAYS—NO EXPENSE

Machinery around a cement plant generally takes an unusual beating, which makes this story of Fast's Coupling service of added significance. In 1923, a plant of a leading Portland cement company installed a No. 5 Fast's Coupling, connecting a fan for a waste heat boiler to a 160 HP, 510 rpm. motor. There is generally a mid-winter shut-down of from two to three months, but otherwise, operation of the equipment has been continuous. According to the Chief Engineer of all plants, and the Superintendent of the plant where this coupling is serving, the Fast's Coupling has never caused any interruptions to service, or any expense.

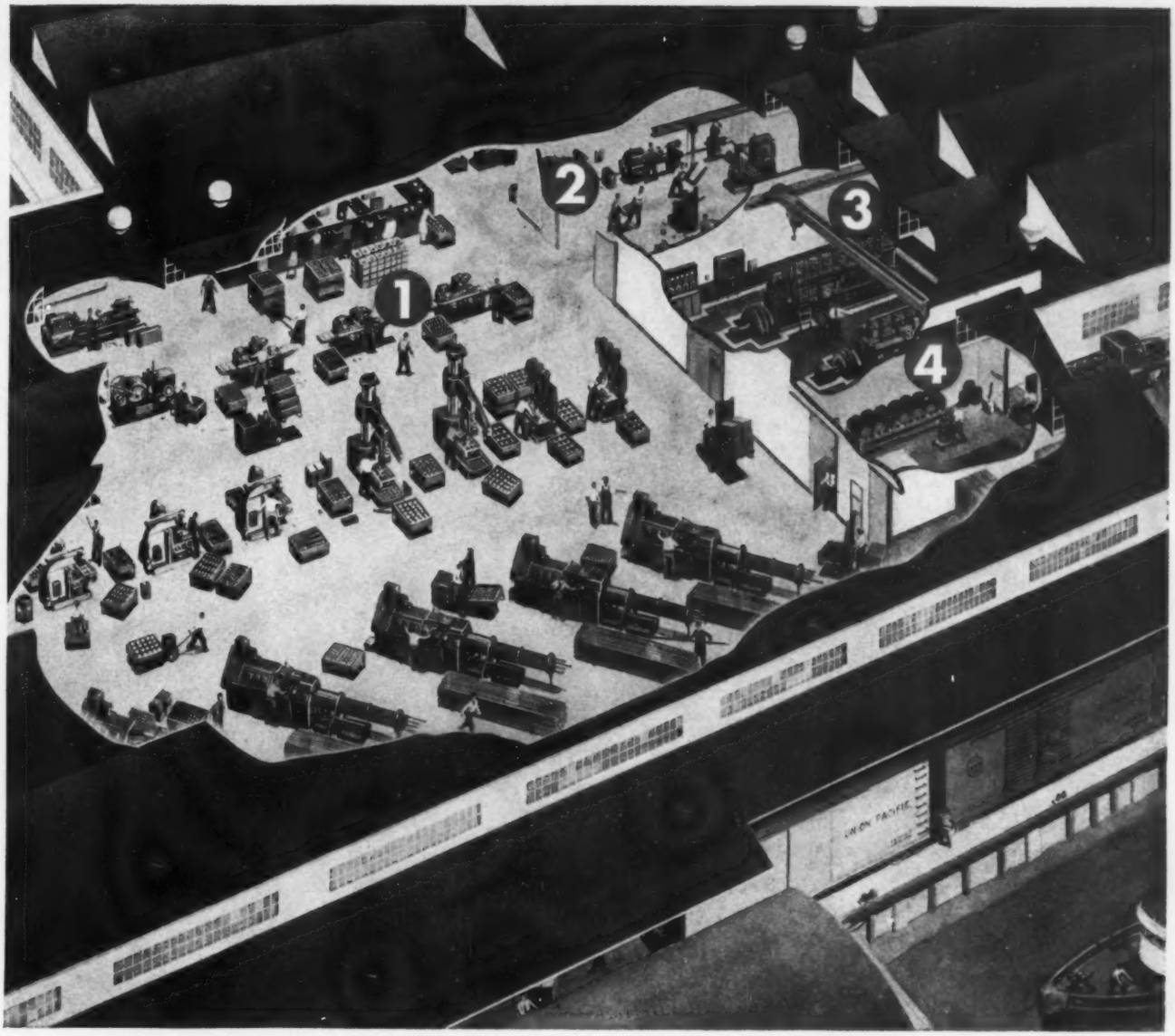
There are a total of 72 Fast's Couplings installed in the various plants of this company. Of these, 46 have been in use 20 years or more, 14 have served for 15 years, and 7 for more than 10 years.

When you are looking for dependable, trouble-free couplings, records like this provide the safest, most dependable guide an engineer could want. Ask for a catalog, listing types and sizes. Bartlett Hayward Division, Koppers Company, Inc., Baltimore 3, Md.



Here you see the features that give Fast's Couplings their remarkable dependability. All parts are protected from wear by a positive film of oil. Oil purity is guarded by rocking bearings, located in the one position where they maintain a positive metal-to-metal seal. There are no perishable parts in "Fast's."

a KOPPERS Product



Find these hidden Profits... inside your plant!

1 MORE CONTINUOUS PRODUCTION

Vital factor in any production picture is steady, uninterrupted machine operation. Socony-Vacuum Correct Lubrication assures peak machine efficiency and greater overall production.

2 LOWER MAINTENANCE COSTS

Correct oils and greases prolong machine life, reduce production losses due to "downtime", minimize repair bills. This means important savings, increased profits.

3 REDUCE POWER CONSUMPTION

By reducing friction losses, Socony-Vacuum lubricants cut power waste. In the power plant, correct oils keep turbines, Diesels, steam engines and air compressors operating at peak efficiency.

4 LOWER LUBRICATION COSTS

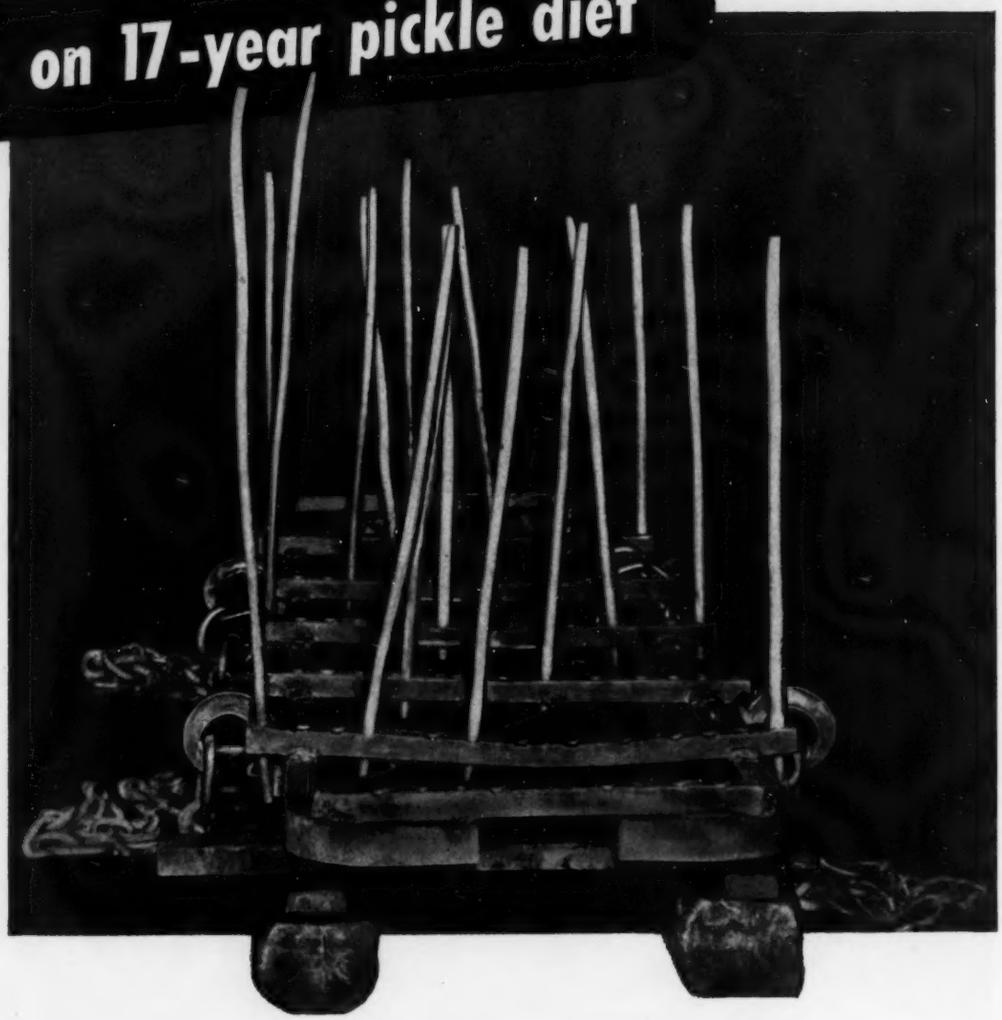
Quality lubricants stand up longer, give maximum protection with minimum consumption. Ultimate lubrication costs are lower. Get these profits for your plant.

GARGOYLE
Lubricants

Socony-Vacuum Oil Company, Inc.

and Affiliates: Magnolia Petroleum Company, General Petroleum Corporation

Thrives on 17-year pickle diet



STILL GOING STRONG
after 17 years in corrosive pickling acids. This Monel crate is one of 25 fabricated in 1929 for an Ohio steel plant by The Youngstown Welding & Engineering Company, *Youngstown, O.*

Long life was built into this pickling crate 17 years ago.

That's why it's still on the job in an Ohio steel plant.

Made in 1929 by *The Youngstown Welding & Engineering Company,* Youngstown, Ohio, the crate was one of a lot of 25. It would be worth a second look even if it were the *only* survivor.

But it isn't! Fourteen others are also making daily trips into the hot acid baths.

Good crates? You bet they are! But their performance didn't just *happen* to be good. *Youngstown Welding & Engineering* made the crates of Monel*, knowing that this rugged nickel alloy would

— resist corrosion by pickling acids
— retain its strength and toughness
— provide long, dependable service

Look closely. You'll see that standard mill forms were used for construction. That's another of the many advantages of Monel. You can almost always use mill forms, even for specially designed equipment. In any form (flat, round, bar, rod, angle or channel) Monel is easily bent and shaped. It can be cut and machined; then riveted, welded, soldered or brazed.

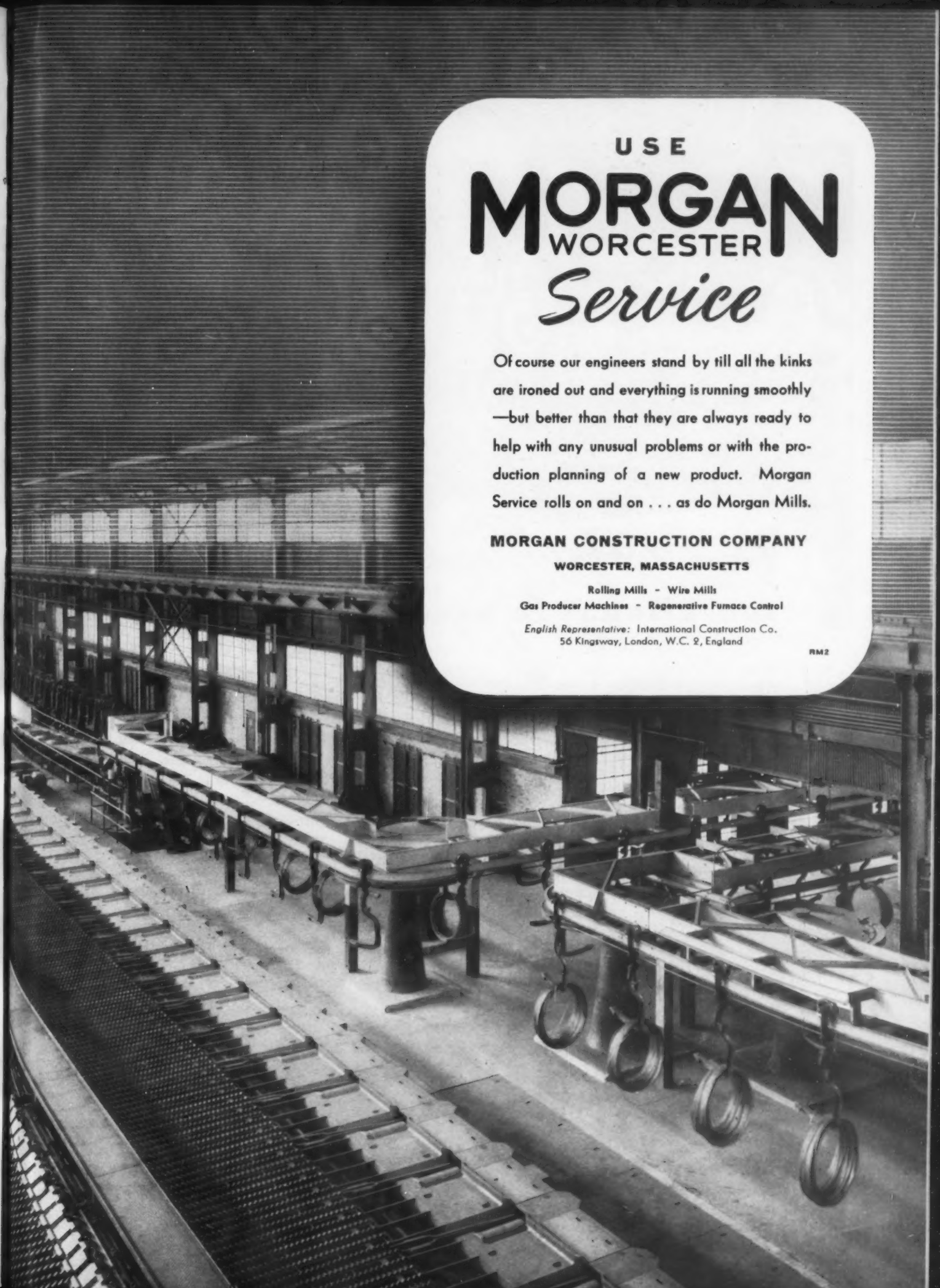
Monel equipment lasts for years in the pickling room. Requiring a minimum of repair, it keeps maintenance costs low.

Use Monel for crates and baskets, racks, hooks and accessories. Then you'll have sturdy equipment that will carry a greater load with greater safety . . . for a longer time.

*Reg. U. S. Pat. Off.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK 5, N.Y.

***Monel*... ONE OF THE INCO NICKEL ALLOYS**



USE

MORGAN WORCESTER

Service

Of course our engineers stand by till all the kinks are ironed out and everything is running smoothly —but better than that they are always ready to help with any unusual problems or with the production planning of a new product. Morgan Service rolls on and on . . . as do Morgan Mills.

MORGAN CONSTRUCTION COMPANY

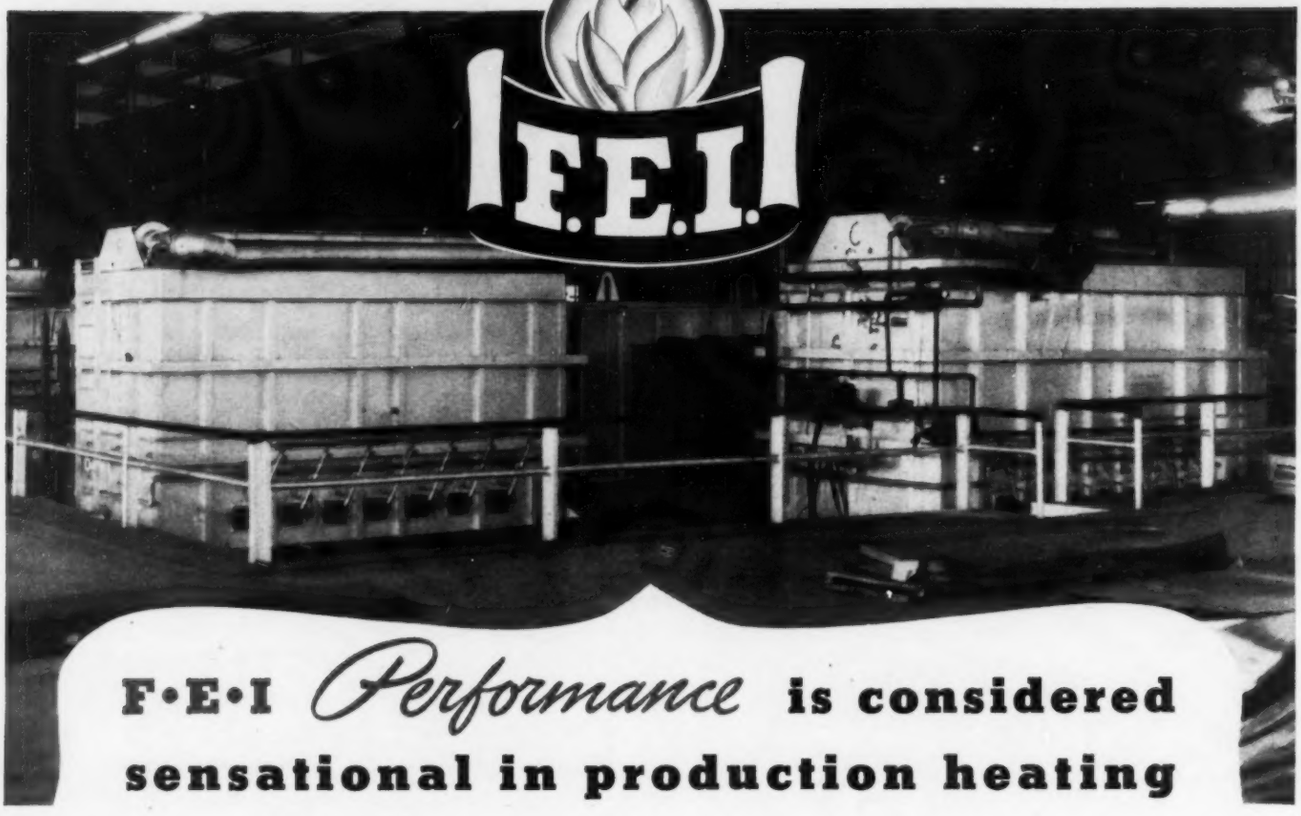
WORCESTER, MASSACHUSETTS

Rolling Mills - Wire Mills
Gas Producer Machines - Regenerative Furnace Control

English Representative: International Construction Co.
56 Kingsway, London, W.C. 2, England

RM2

EVEN IN THIS AGE OF PRODUCTION WONDERS



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EXAMPLES AND APPLICATIONS:

(a) 1. 14400/13200. Winding (1-Ph or 3-Ph) tapped for 13200 volts.

(b) 2. 7200/12470Y. Winding (1-Ph or 3-Ph). May be connected for either 7200 volts delta or 12470 volts Y.

(b) 3. 12470Y/7200. Winding (3-Ph) designed for 12470 volt Y connection with 7200 volts available from line to neutral. (Neutral brought out.) 208Y/120. 208 volt Y connection with 120 volts available from line to neutral.

(b) 4. 12470 Grd. Y/7200. Winding (1-Ph) can be connected either from line to neutral on a 12470 volt grounded Y circuit, or from line to ground on a 7200 volt 1-phase circuit with one line grounded.

(c) 5. 120/240. Winding (1-Ph) suitable for either 120 volt multiple connection, for 240 volt series connection, or for 240/120 volt 3-wire connection.

(c) 6. 240/120. 240 volt winding with mid-tap for 3-wire connection.

X The **x** is used between voltages of a series-multiple winding which is not designed for three wire operation.

EXAMPLES:

1. 240 x 480. Winding suitable for 240 volts multiple connection or 480 volts series connections but not suitable for 480/240 3-wire connection.

2. 240/120 x 480. Winding suitable for connection for either 240 or 480 volts —the 240 volt connection having a mid-tap for 3-wire connection.

— The **dash** is used between voltages in separate windings, i.e. between primary and secondary (and tertiary if three winding).

EXAMPLE:

1. A Y—Y connected three phase transformer with delta tertiary winding and with primary and secondary neutrals brought out, should be written: 115000Y/66400—13800Y/8000—34500 volts.

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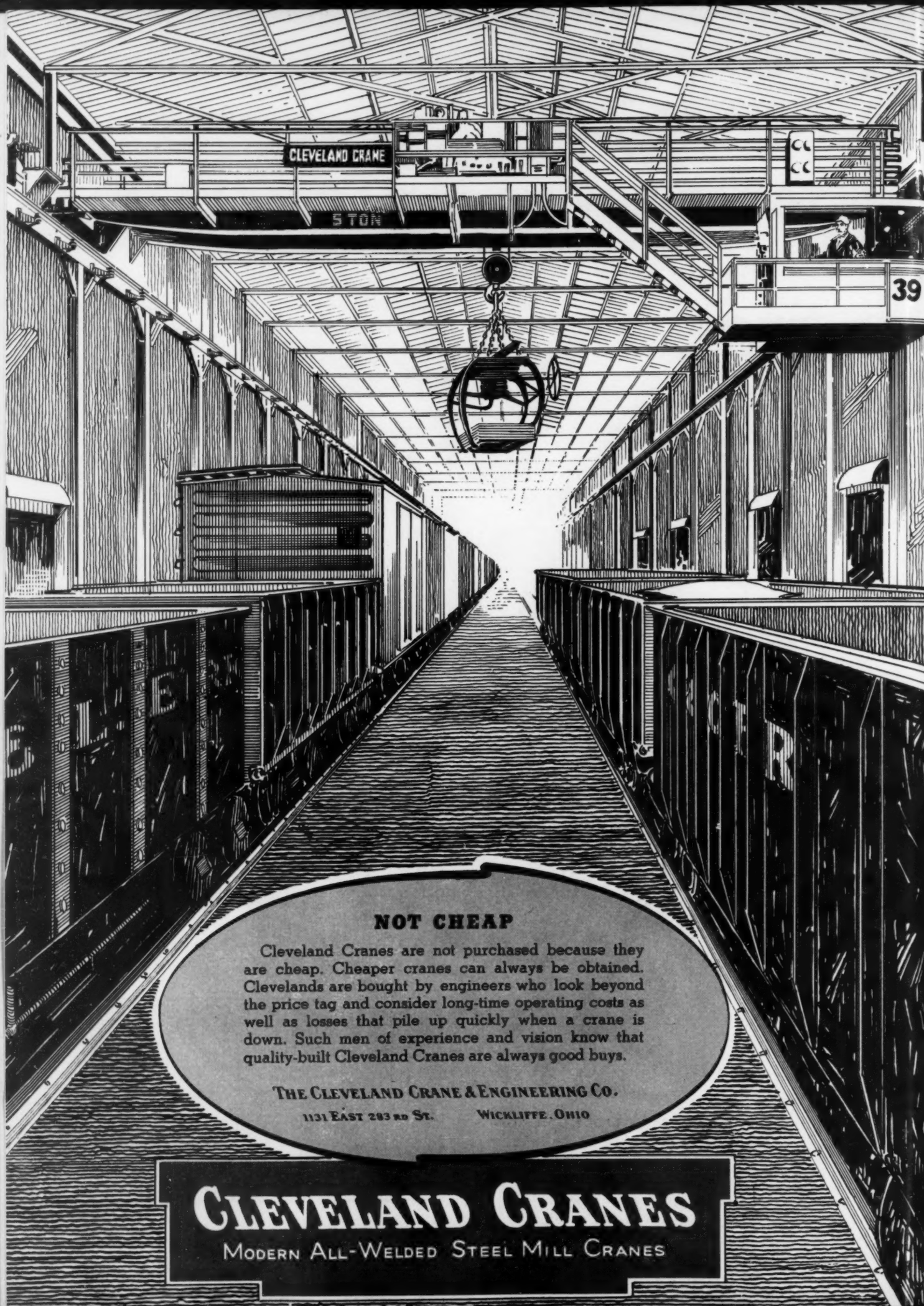

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Crops *and* Shorts

FIRST quarter profits of 22 steel concerns averaged about 50 per cent below the first quarter of 1945. At first glance, this appears better than might be expected in the face of the steel strike, but it must be remembered that these earnings were bolstered by tax adjustments, reductions in depreciation and reductions in reserves.

Although coal and rail strikes make second quarter prospects appear none too good, optimism nevertheless prevails that the expected boom in automobiles, appliances, construction, etc. will bring happier times.

▲

THE U. S. Department of Commerce reports that iron and steel and electrical machinery were the only industries reporting reduced dividend payments in the first quarter as compared with the first quarter of 1945. Always did think we were in the wrong business.

▲

A REPORT issued by the British Iron and Steel Federation and published in Iron Age predicts a total expenditure of $672,000,000 over the next seven years for modernization and rehabilitation programs in the British steel industry. The plan calls for building 24 new blast furnaces, a large strip mill, three cold strip mills, a structural mill, two plate mills and five billet mills, meanwhile scrapping many old, uneconomical units. Approximately $25,000,000 is slated to be imported from the United States.

▲

A RECENT issue of This Week states that the highest number that has a name is 999-odd vigintillion, written 999,999,999,999,999,999,999,999,-999,999,999,999,999,999,999,999,999,999,999,999,-999,999,999. Add one to this figure and they say that even Einstein would not know what to call the result. According to our high-school algebra, all you have to do is let $x = 999$-odd vigintillion and call the result $(x+1)$. Even more fascinating, think of $(x)^2$ — or even $(x)^{10}$. And we'll stake our last year's auto license that our administration in Washington has someone working on names higher than vigintillion in order to express our national debt, come the year 2000.

ACCORDING to the American Iron and Steel Institute, hourly earnings of workers receiving hourly, piecework or tonnage wages in the steel industry hit a new high of $1.351 per hour in March in spite of overtime reduction.

▲

AND speaking of wages, Philip Murray has served notice that a guaranteed annual wage will be the No. 1 request when discussions are opened this fall on the steel workers contract. Incidentally, Murray promised rigid adherence to the existing contract, which runs until February 14, 1947 — then maybe we'll get a nice valentine.

▲

THINKING a bit about a guaranteed annual wage, we have just witnessed what the coal strike and the rail strike did to steel production. In such cases, the steel industry has no control over its own operations, but with a guaranteed annual wage, the industry would have to pay its workers who could not work because of strikes in other industries. Then, if the unions could get together on a schedule of consecutive strikes, they'd never have to work.

▲

A CALIFORNIA employer recently picketed the United States Employment Service Office in Los Angeles, carrying signs offering free employment service and enumerating a variety of trades and skills that were in immediate demand. Although 150,000 individuals are now collecting unemployment compensation in that county, he could persuade only four to take jobs.

▲

IT has been reported that the duty of the chief shop steward at the Skoda works in Czechoslovakia is to patrol the shops to see that the men do their full measure of work. If all shop stewards performed this function, managements wouldn't object to paying the stewards' wages.

▲

UNITED STATES readers spend over 1⅓ billion dollars annually for newspapers, magazines and books. Now, if we would just learn to think as much as we apparently read, we might get back into some semblance of sanity.

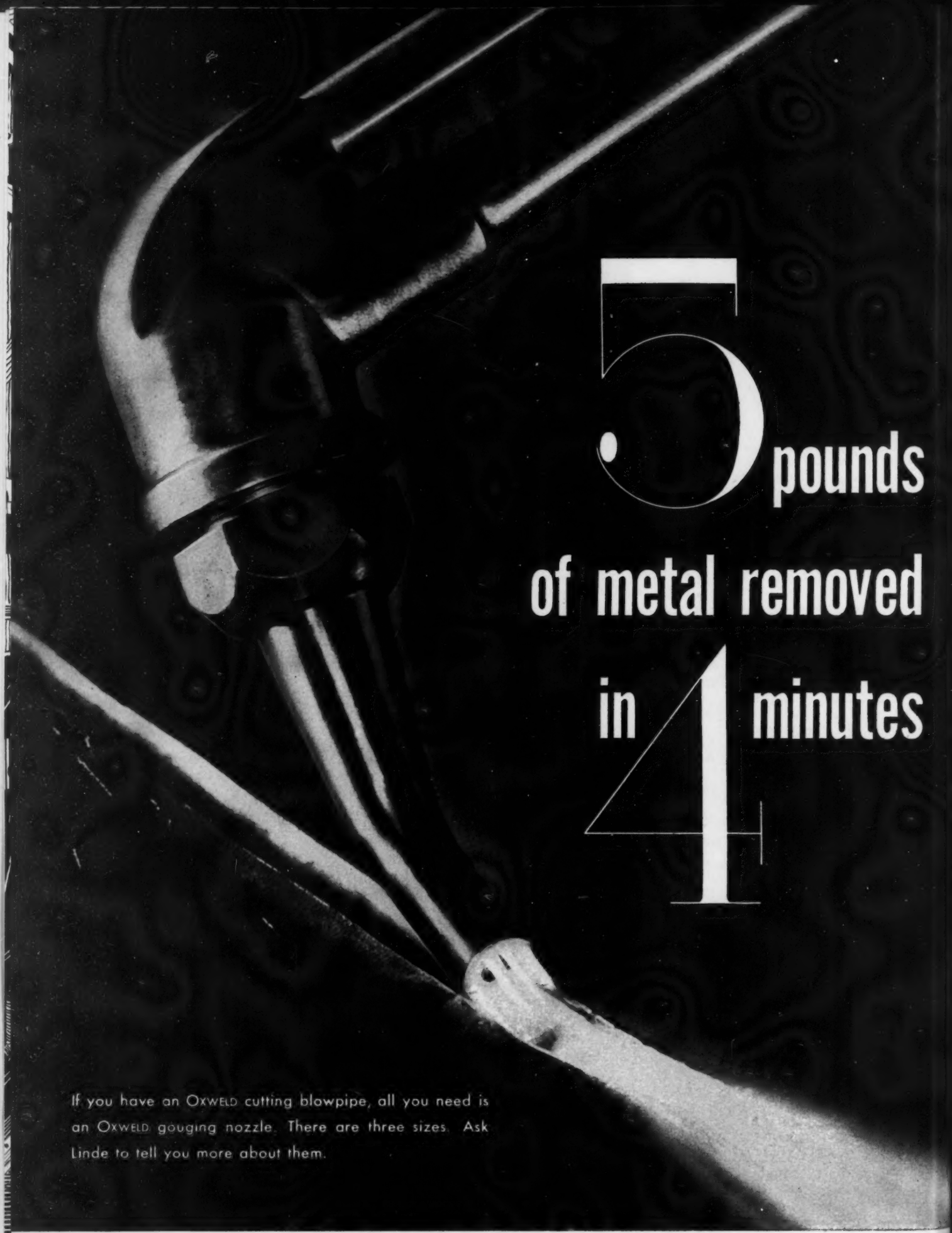
▲

A RECENT issue of the Kablegram tells of a young author who asked an editor for his definition of the perfect short story. The editor replied that it must be (1) short and to the point; (2) contain a religious touch; (3) have some reference to the aristocracy; (4) have action; (5) possess sex appeal.

Accordingly the author sent along the following: "Heavens!" said the duchess. "You're pulling my leg."

▲

A TRIBUTE to American industry is found in the report that the standard 105 mm howitzer field piece of the United States army fired 16,000,000 rounds during a three-year period with only eight malfunctions and not a single casualty to the operating personnel.



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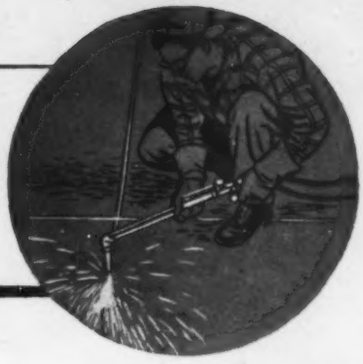
1 It is a faster way to groove weld joints to receive backing-up welds . . . 36 to 48 in. per min. (gouging time).



The bottom shell on a T-2 tanker is prepared for welding at the rate of 16 in. per min. (hourly average).

2 It is a quick and easy way to remove temporary or defective welds.

The operator is removing studs that were used to clamp a testing head to a pipe section.

3 Parts shaped by flame-gouging frequently require no machining before use.

This shaft end, 3 in. wide and 12 in. long, is quickly grooved to fit a clutch.

4 It is a fast way to open up cracks in castings for welded repair or to modify forgings and castings.

This 18½ ft. crack in a cone crusher was gouged out to sound metal in only 4¾ hours.

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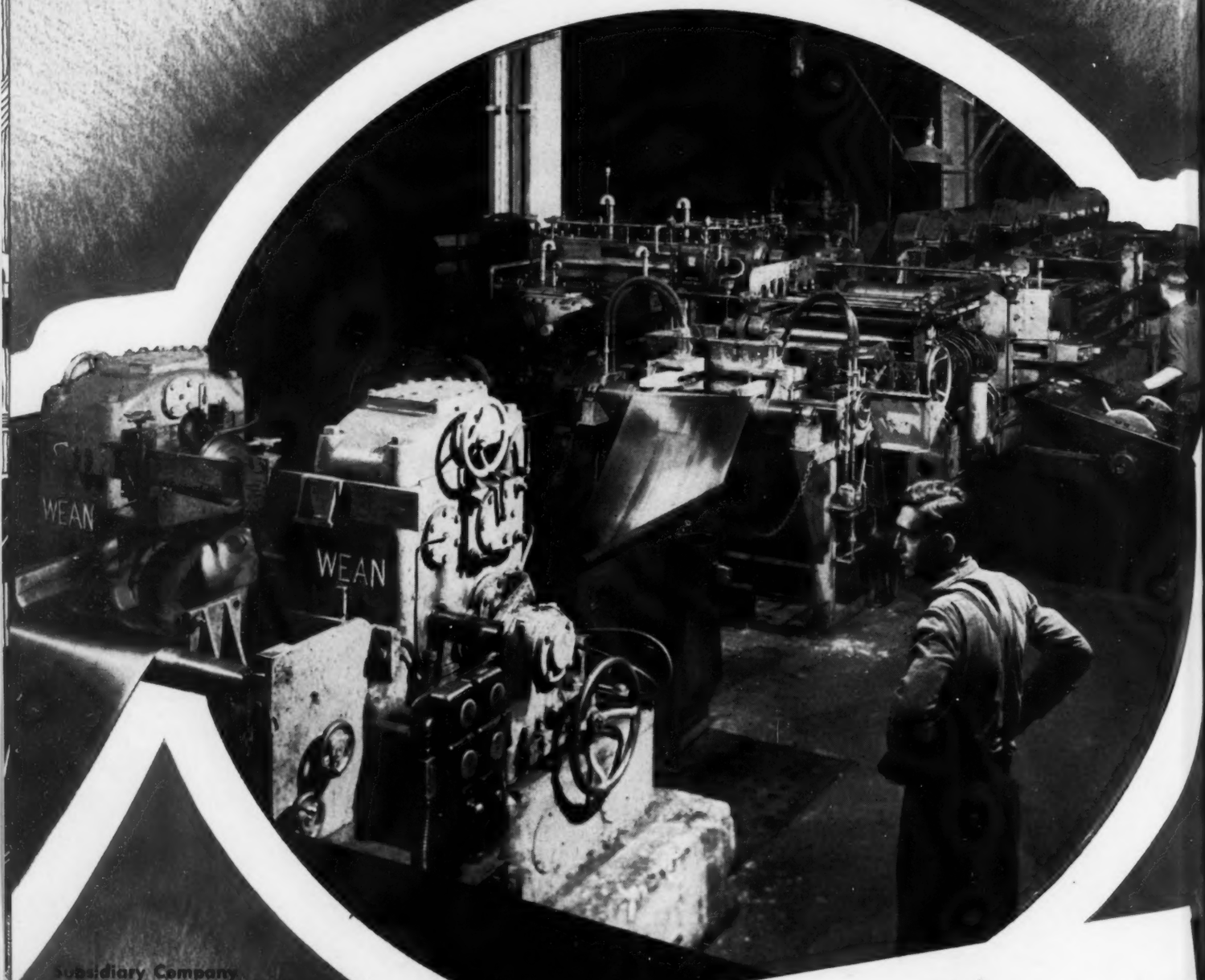

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Iron and Steel ENGINEER

JUNE, 1946 VOL. XXIII NO. VI

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Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879
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Rail Mills AND RAIL MILL Roll Design

. . . . with this review of the development and design of rail mills, Mr. Beynon adds a fourth chapter to his previous comprehensive papers which dealt with bar mills, blooming and billet mills, and structural mills . . . .

by Ross E. Beynon, SUPERINTENDENT
ROLL SHOP DIVISION
CARNEGIE-ILLINOIS STEEL CORPORATION
SOUTH CHICAGO, ILLINOIS

▲ THIS paper is intended principally for those who are not thoroughly familiar with rail mills and rail mill roll design. The historical data incorporated may be of general interest.

The invention of the locomotive and its use necessitated stronger and better tracks than had been in use for horse drawn and manually propelled vehicles. The earliest tracks on which metal was used consisted of a wooden base with flat straps of cast metal nailed to wooden stringers as shown on Drawing 1, Figure 1. Later, a rolled iron strap was used. This soon proved inadequate and many improvements of the strap type rail were developed, one of which is shown in Figure 2 of the same drawing. This type rail was rolled for the Amboy division of the Pennsylvania Railroad as late as 1831.

The next development in wrought iron rails was the work of John Birkenshaw of the Bedlington Iron Works, England, in 1820. This rail consisted of a head and web but no base, and was laid on the ties in a cast chair, Figure 3 of Drawing 1. Such rails were used on the Stockton Darlington Railway in 1825. Figure 4 shows the rolls used to produce this rail, while Figure 5 shows a more advanced design. The latter rail was rolled and used in Great Britain and was also used in this country on the Boston and Lowell Railroad in 1830.

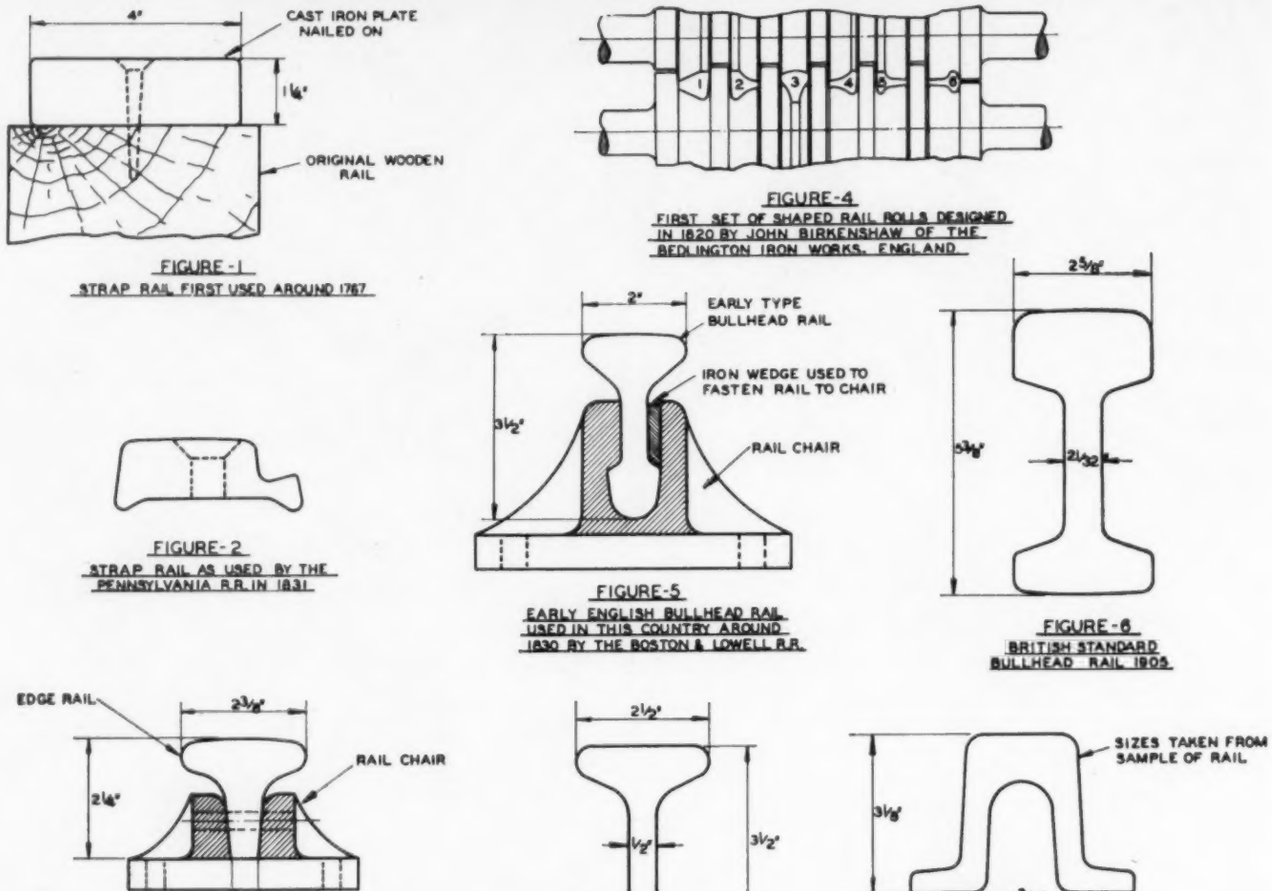
The tee rail has never been popular in England. Rail development there has been based on the belief that the rail should be supported in a chair, and even now, the English standard is the bullhead rail shown in Figure 6 of Drawing 1.

In America, Robert L. Stevens of the Camden and Amboy Railroad designed the first tee rail in 1830. These were rolled in Great Britain in 1831, and are shown in Figure 7.

Figure 8 illustrates the U-rail, a popular type rolled by the Mount Savage Rolling Mill Company of Allegheny County, Maryland, in 1844. These are reported to be the first shaped rails to be rolled in this country. This rail, when made of iron, rolled very satisfactorily. The shape was such that the rail base could be rolled from the iron pile without collaring the rolls, which was often experienced when rolling tee rails from iron piles. Later in 1844, or early in 1845, the Mount Savage Rolling Mill Company produced tee rails. The Montour Rolling Mill Company of Danville, Pennsylvania, began the rolling of tee rails at this time and there is some doubt as to the original producer.

Drawing 2 shows the roll passes used for U-rails in England about 1855.

Presented before the Chicago Session of AISE Annual Meeting, October 1, 1945.



Drawing 1 — Early forms of rails and rail rolls.

Many different rail designs were tried in this formative period. In fact, there were almost as many different ideas about rails as there were railroads. One which enjoyed a very brief life is illustrated in Drawing 3. This rail was rolled of iron at the Cambria Iron Works on May 6, 1859 and had a hollow head. History does not say how many of these rails were made. In America the tee rail gradually supplanted rails of other types and became the standard.

As late as 1857, rail roll trains were all two-high and of the "pull-over" type, i.e., after a bar had been run through the rolls, it was necessary to pull the bar back over the top roll in order to re-enter for the next pass. This is illustrated in Drawing 4, Figure 1. Much thought was devoted to eliminating these idle passes. Wilkinson, in 1792, had patented a mill consisting of two rolls approximately 60 in. in diameter by 71 in. long, shown in Figure 2, Drawing 4. The top roll of this mill was actuated by a crank which moved back and forth, pulled and pushed by the piston of an engine. This caused the top roll to turn to and fro, presenting a rolling surface of about 50 in. The bottom roll was not driven but was moved by friction of the puddled piece. This mill was operating in 1802. The piece was rolled back and forth between the two rolls until it was too long to roll. Limited length of the piece resulted in the failure of this method. Thomas Ellis, however, continued work on this design in 1857, and in 1863 J. Ramsbottom built several of these mills with some modification, Figure 3 of Drawing 4. "A" shows segment rolls actuated by piston and a steam cylinder and both rolls are driven. "B" shows a rack and pinion arrangement where the bottom roll only is driven. "C" shows the roll pass layout. These mills, however, were not widely used.

Figure 4 of Drawing 4 shows another development for eliminating idle passes. This is the Dowlais mill, sometimes known as the "Double-Duo" mill. The four rolls are contained in one housing and geared to run as indicated on the drawing. Although idle passes were eliminated, it required four rolls and some rather complicated gearing equipment to accomplish it. Many of these mills were used as bar and skelp mills, and a number of this type are still in operation in this country.

The Brown Mill was another developed to avoid idle passes, see Figure 5. In this scheme there were four rolls, two pairs arranged in tandem, close to each other, with each pair rolling away from the center. The bar was idled through an enlarged groove of number 1 set, then entered the working pass in the number 2 set. In order to return the bar, it was transferred sideways to the next groove, idled through the No. 2 stand and then entered the working pass in number 1 stand. This procedure was then repeated through the various passes in the roll stand.

Still another mill, credited to Cabrols Colamineur, was developed about 1850 and is shown in Figure 6. This mill consisted of two trains of rolls set as shown on the drawing, each set rolling opposite directions. The bar was given a pass in the number 1 set where it was rolled back, then transferred to the number 1 set and rolled forward. This operation was repeated as many times as was necessary. The two stands were run by the same engine through suitable gearing. Figure 7 shows another variation of this idea. In this case the two trains are in line and each is driven by its own engine. It is said that a blooming mill of this same general type still operates in this country.

The reversing mill was developed by Ramsbottom, Crewe Works, of the London and Northwestern Railway in 1866. This was a two-high mill and is credited with being the first to utilize a reversing engine. Other ideas were developed along this line where the engine was non-reversing, but gearing and clutches were used to reverse the mill.

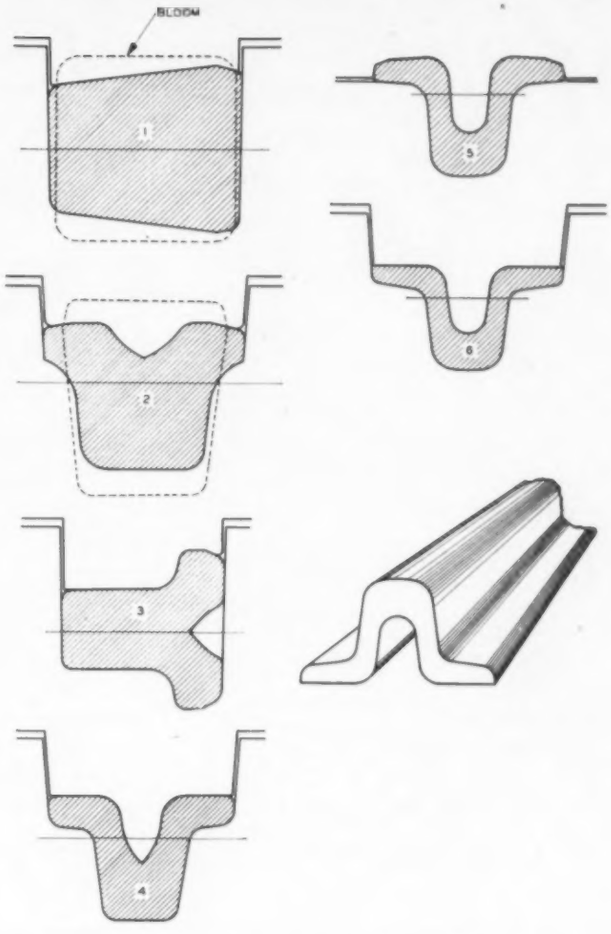
In 1857, Mr. John Fritz of the Cambria Iron Company of Johnstown, Pennsylvania, while watching a two-high pull-over mill in operation rolling rails at that plant, conceived the idea of putting a third roll on top of the other two rolls thus making the stand three-high and eliminating the idle pass back over the top roll as was the practice on the two-high mill. The Fritz mill is shown in Figure 8. This innovation was entirely successful and several iron blooms were rolled into rails on July 29th of that year. By 1866, a great many of the two-high rail mills in the United States had been changed to three-high. This was one of the greatest improvements made in rolling mills, and for many years, three-high rail mills were known as the Fritz type mill. Drawing 5, Figure 1 shows the three-high rolls used by Fritz.

Fritz's three-high mill featured the rolling of rails from the bloom or pile in seven passes with hanging guides on the top roll.

It was necessary to use the hanging guides for the pass back as shown on Drawing 5. These hanging guides were considered by operators of the period to be dangerous, even though their use on this mill was a success.

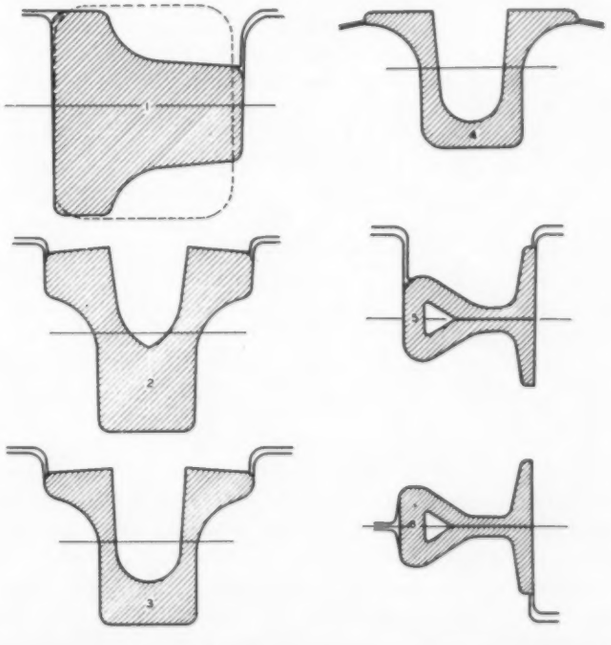
In the same year, 1857, an English mill for rail rolling was designed which was also three-high, but made the rail in five passes and featured resting guides throughout and is shown on the bottom of Drawing 5. In order to avoid the use of hanging guides and alternate live and dead holes in this mill it was necessary to turn the bar over between passes.

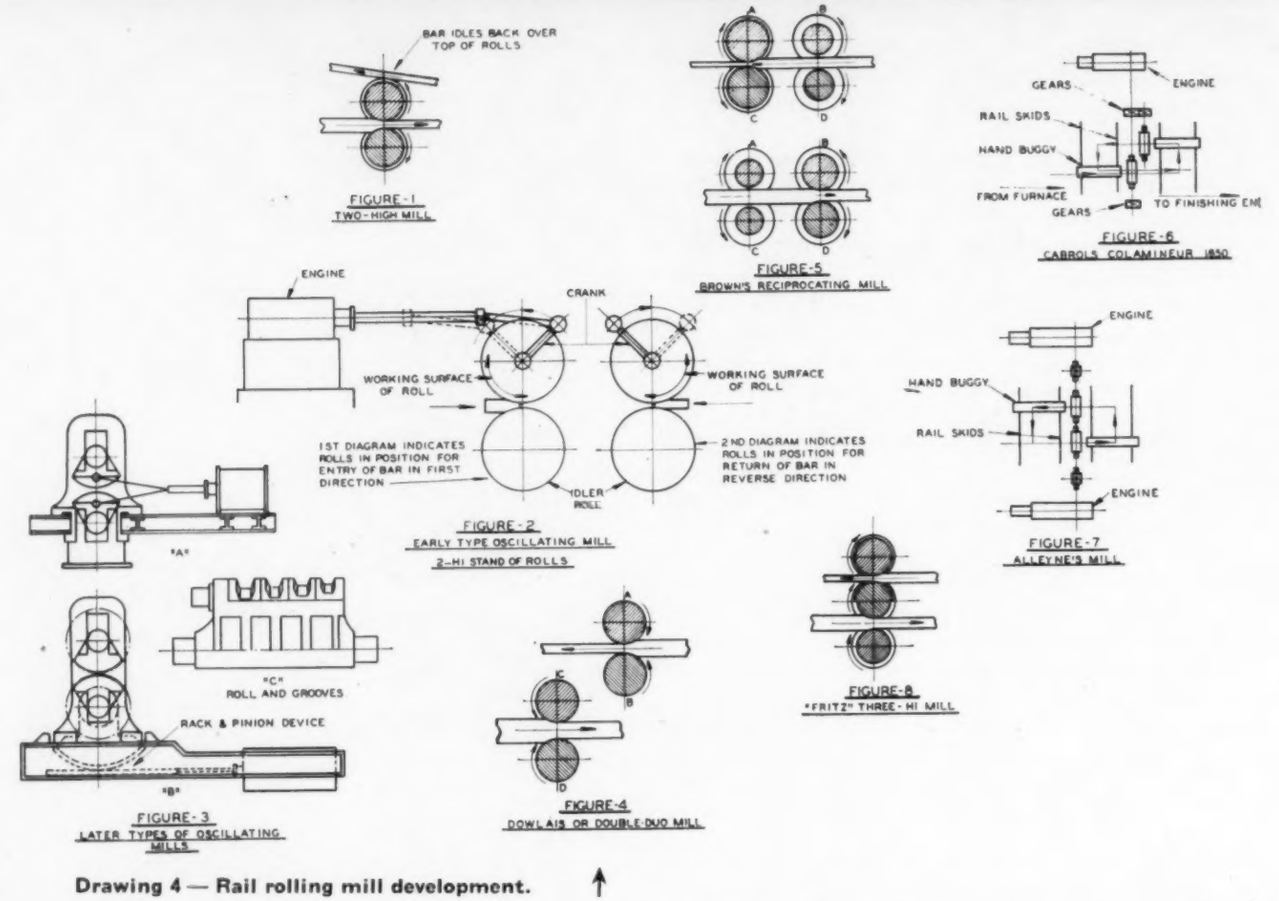
Hanging guides used by Fritz were thought to be a new invention as their use was unknown in America at the time. However, John Hazeldine of England had



Drawing 2 — "U" rail rolled in England in 1855.

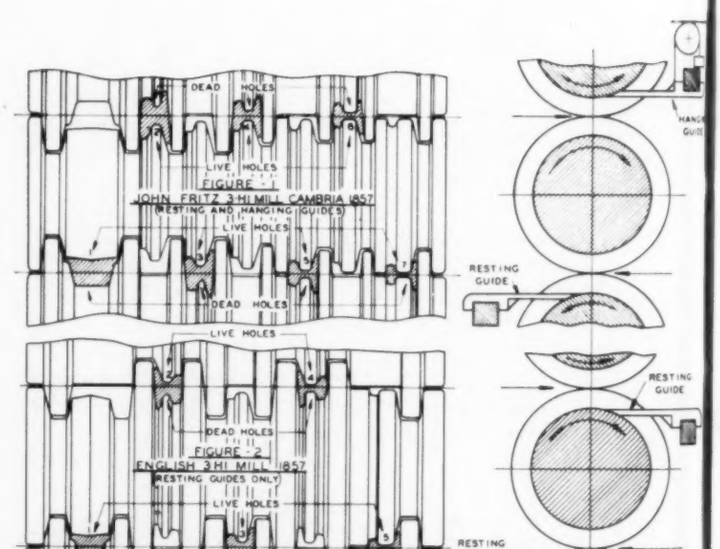
Drawing 3 — Hollow iron rail rolled in 1859.





Drawing 4 — Rail rolling mill development. ↑

Drawing 5 — Early 3-high rail rolls. →



used them in his patented two-high continuous roughing mill in 1798. Hazeldine obtained patents covering three mills which were designed to quickly weld the iron pile of the period. The first design had three horizontal continuous roll stands. Note the hanging guide on the second stand shown in Figure 1 of Drawing 6. The second design had five continuous stands, alternately horizontal and vertical, but there are no hanging guides shown, see Figure 2. The third mill shown in Figure 3 and patented by Hazeldine is worthy of mention as it was the most original of the three. This mill consisted of a cluster of horizontal rolls. The center roll was of a large diameter and in contact with this roll, three smaller rolls were spaced around the circumference. Between these and the large roll three passes were taken. Channel guides conducted the bar around and held it against the large roll. The hanging guide again appears in this design.

The continuous mill originally patented by Hazeldine was repatented in 1861 by Charles While of Great Britain, for use as a roughing mill for iron rails. It is shown in Figure 4. There were reputed to be ten to twelve of these mills in use in Wales.

It is surprising to learn of the large number of mills that were built to roll rails as their principal product in this country. Sixty-nine mills were reported to be rolling rails of various weights in 1874. During this great railroad expansion period, rails were in such demand that even this large number of mills could not supply the demand. These mills were scattered around the country with one as far west as Laramie, Wyoming.

One of these mills rolled bessemer rails exclusively, seven rolled iron and bessemer, two mills rolled steel headed rails only, two mills rolled steel headed rails and iron rails, and one produced cast steel rails and also rolled iron rails. Of these sixty-nine mills, thirty-five made heavy rails and thirty-four made light rails.

The tonnages produced on the old mills were small in comparison to present-day methods. For example, in 1875, the North Chicago Rolling Mill Company, Chicago, Illinois, was reported to have rolled in two turns (twenty hours and four minutes of actual rolling time) 1010 blooms of bessemer steel rails. These were rolled into 60 pound rails each 30 feet long. Total weight was 270 tons with only ½ of 1 per cent second quality rails. This tonnage was considered very good at the time because the mill had only eight heating furnaces of a capacity of nine blooms per furnace.

EARLY RAIL MILLS

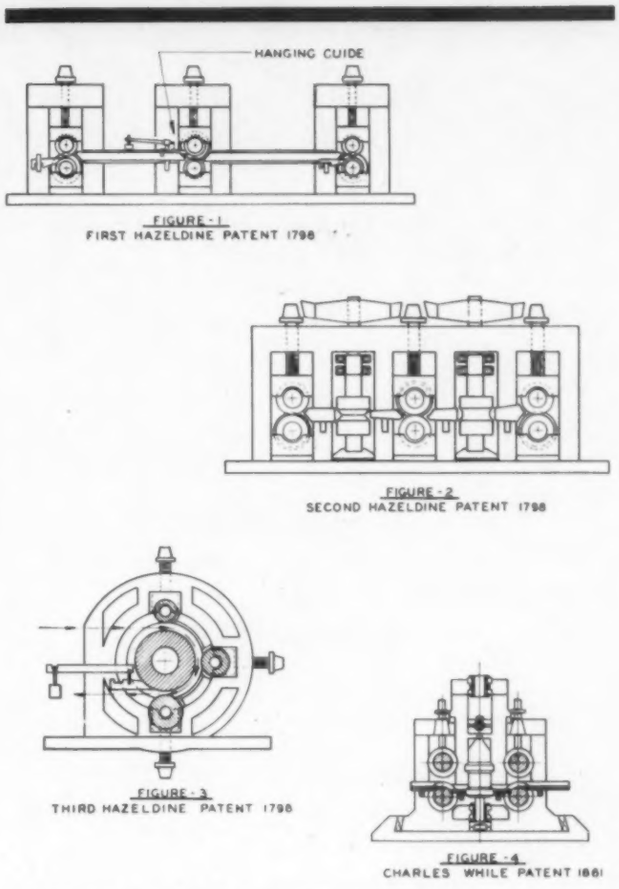
There does not seem to be much accurate information available about the first mills which rolled rails. It is probable that existing mills designed to roll bars were utilized with such alterations and additions as were necessary. Drawing 7 shows a Belgian mill of 1835. This was considered at that time to be a very complete installation. It was a combination mill with one engine driving two roll trains. The roll train on the left was a puddle mill and was supplied with both hammer and squeezer. The hammer, squeezer, and shear were operated by the mill engine. On the right hand side of the engine was the mill used to roll rails. The hammer was used to forge some of the puddle iron stock into blooms for rolling into rails. In other cases it appears that puddled iron piles were also used. The roll trains were of the two-high, pull-over type.

In many of the early mills such as this one, the puddle ball became too cool to roll after the squeezing and hammering operations, and it was necessary to reheat the piece in the reheating furnaces in order to roll the puddle bar or bloom. The two hot saws shown in the drawing were designed to trim both ends of the rail simultaneously, the saws being set the proper distance apart. The rails were moved against the saw on a movable carriage.

The passes shown in Drawing 8 are for a U-rail rolled at this Belgian Plant in 1840. It seems that this would have been a good opportunity to use a puddled and hammered bloom because the first pass would readily take such a bloom on edge.

The rolling of rails from iron piles was at best a difficult matter, and even with the best practice, the iron was soft and wore easily. The head of the rail naturally received the most abuse from the wheels of the trains passing over it and wore out rapidly. To improve the wear of the head, various expedients were adopted of which the most popular was to use double or triple refined iron for the top and bottom of the pile and single or double refined, or scrap iron for the center. The top of Drawing 7 shows such a pile used for rolling rails. This is of the 1840 period, and was used at the Couillet Iron Works in Belgium. A indicates the parts made of double refined iron, B the parts made of single refined iron, while C was made of flats rolled from scrap rails. These piles were 5.9 in. to 7.8 in. square, and 35.4 in. to 47.2 in. long, and weighed 330 pounds to 660 pounds according to the size and weight of the rail rolled.

Among the British rail mills of the sixties, one of the more important was the Dowlais plant in Wales. Although it was originally built for the production of iron,



Drawing 6 — Early types of continuous rolling mills.

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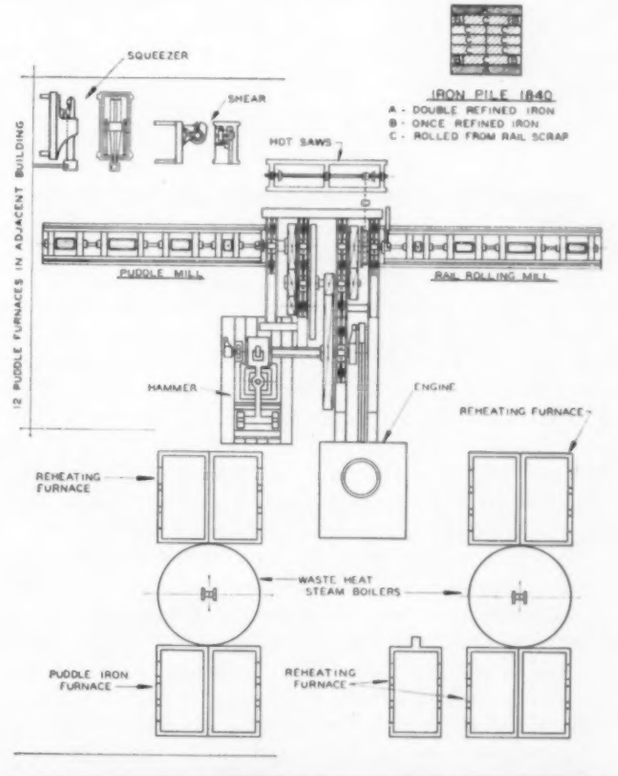
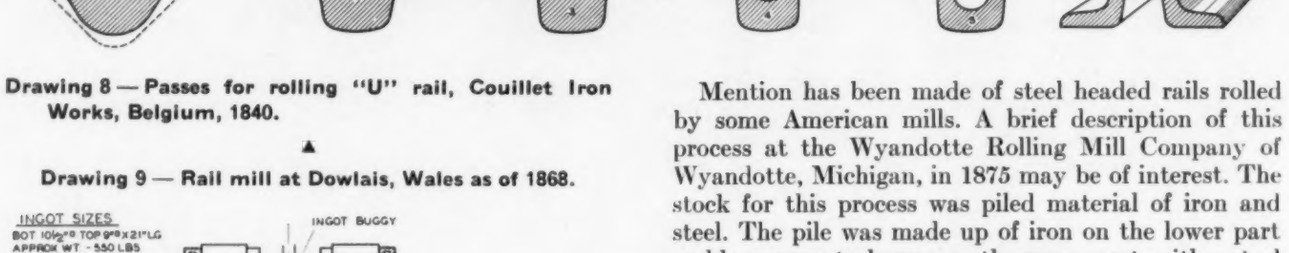
Drawing 7 — Layout of mill, Couillet Iron Works, Belgium in 1835.





Drawing 8 — Passes for rolling "U" rail, Couillet Iron Works, Belgium, 1840.

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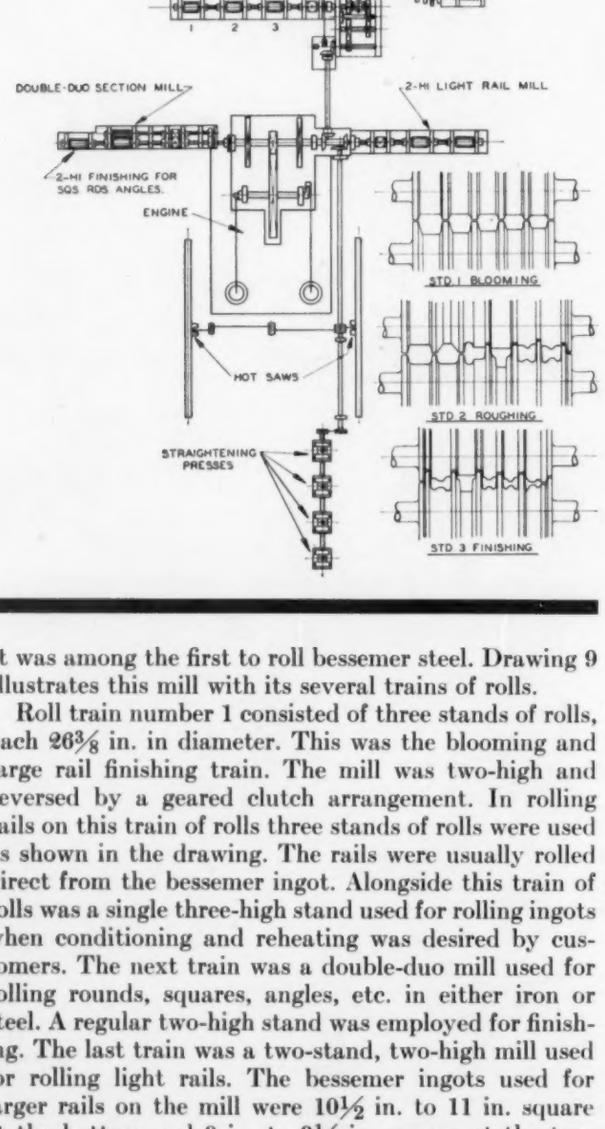
Drawing 9 — Rail mill at Dowlais, Wales as of 1868.



it was among the first to roll bessemer steel. Drawing 9 illustrates this mill with its several trains of rolls.

Roll train number 1 consisted of three stands of rolls, each 26⅜ in. in diameter. This was the blooming and large rail finishing train. The mill was two-high and reversed by a geared clutch arrangement. In rolling rails on this train of rolls three stands of rolls were used as shown in the drawing. The rails were usually rolled direct from the bessemer ingot. Alongside this train of rolls was a single three-high stand used for rolling ingots when conditioning and reheating was desired by customers. The next train was a double-duo mill used for rolling rounds, squares, angles, etc. in either iron or steel. A regular two-high stand was employed for finishing. The last train was a two-stand, two-high mill used for rolling light rails. The bessemer ingots used for larger rails on the mill were 10½ in. to 11 in. square at the bottom and 9 in. to 9½ in. square at the top. The ingots were 21 in. long and weighed 550 to 650 pounds.

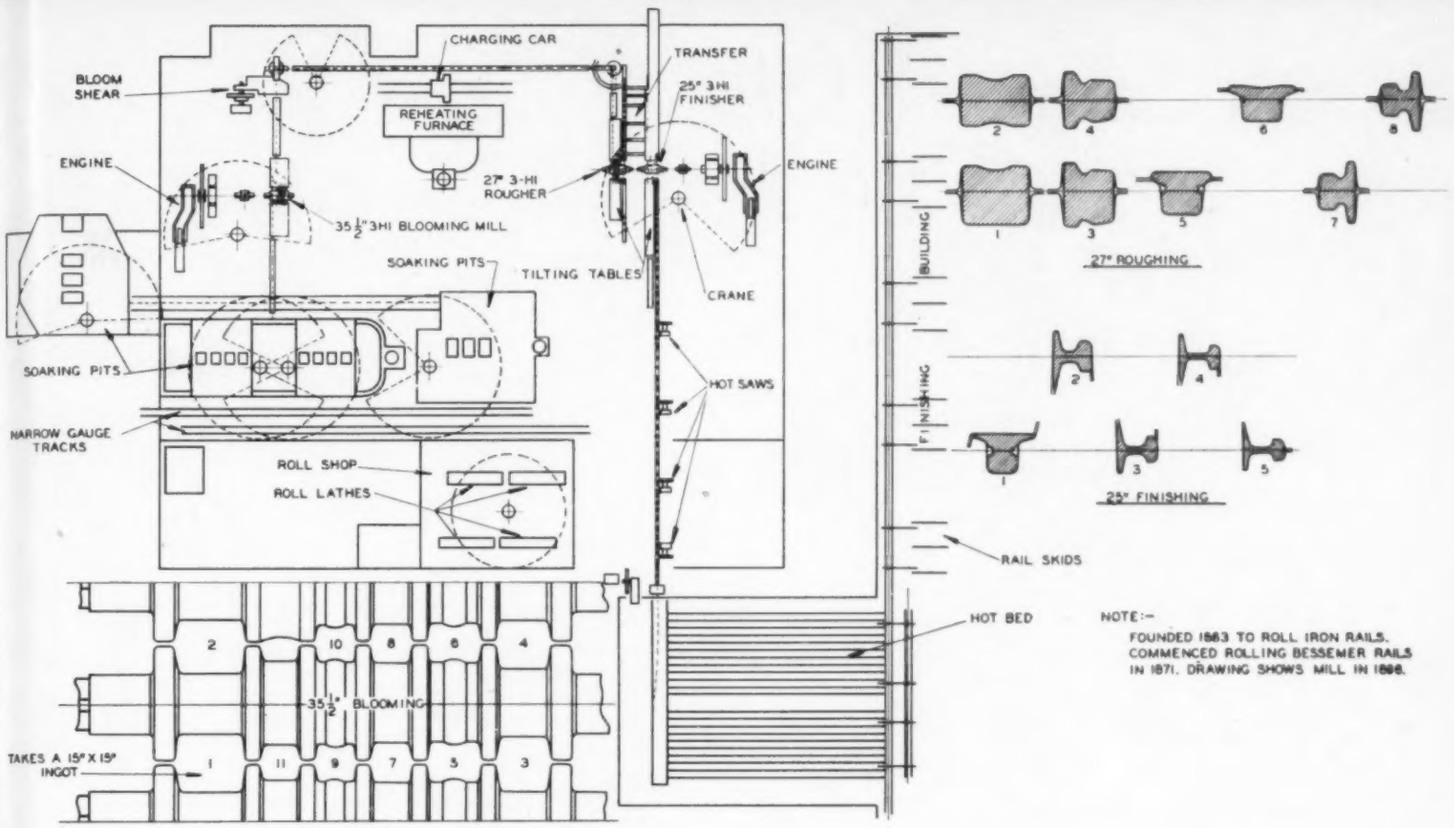
Mention has been made of steel headed rails rolled by some American mills. A brief description of this process at the Wyandotte Rolling Mill Company of Wyandotte, Michigan, in 1875 may be of interest. The stock for this process was piled material of iron and steel. The pile was made up of iron on the lower part and bessemer steel scrap on the upper part, with a steel plate or bar piled on top of the bessemer scrap. The welding flux, in the form of grains about the size of oats, was sprinkled over the pile which was then put into the heating furnace, heated and rolled. Care was taken in the rolling process to keep the steel part in proper position to form the head of the rail.

Another pile which was favorably regarded was one in which plates of iron and steel were welded together under a hammer and used on the top and bottom of the pile with the steel portion on top and bottom and the iron parts toward the center.

Credit for rolling the first steel rail in 1857 is given to the Dowlais Plant, Wales, while the credit for rolling the first steel rail in this country is given to Captain Ward's North Chicago Rolling Mills, where the first bessemer steel rails were rolled experimentally in 1865 from blooms made of hammered ingots produced at Wyandotte, Michigan. Another Chicago rail mill built in 1863, known as the Union Rolling Mill Company, is shown in Drawing 10. This mill was built originally to roll iron rails but was later remodeled to roll steel rails. The drawing shows the mill as it was in 1896, equipped for bessemer rails. Still another mill was built in Joliet, Illinois, about 1871 to roll bessemer rails. In 1881 South Works was built, shown in Drawing 11, also to roll bessemer steel rails. These plants were later consolidated under the name of the Illinois Steel Company.

The rail mill built in 1881 at South Chicago merits some description as it was considered an excellent mill for its time. It consisted of a 40 in. three-high blooming mill and a 26 in. two-high reversing finishing mill, the three-high mill taking an ingot approximately 14½ in. square. The ingots were heated in four flat hearth type furnaces, the inside dimensions of which were 24 ft by 6 ft with six doors. Each furnace held twelve ingots. The ingots were charged and drawn by an hydraulic machine operated by a boy, and were delivered to the blooming train by a hand operated buggy. The bloomer had fifteen passes, eleven of them box passes, and four roughing passes for the rails. Tables on both sides of the mill were of the lifting type.

After blooming and roughing, the piece was run down on driven spools to the finishing rolls 120 feet ahead. The 26 in. finishing train was a two-high reversing mill, engine driven, with stationary tables equipped with tumbling devices, consisting of beveled collars on the table rollers for turning the bars where needed. Sixty feet beyond the finishing mill was a crop shear where the piece was cropped after one pass in the finishing mill. It was then run back to the finishing mill where



Drawing 10 — Old type rail mill, Union Rolling Mill, Chicago, Illinois.

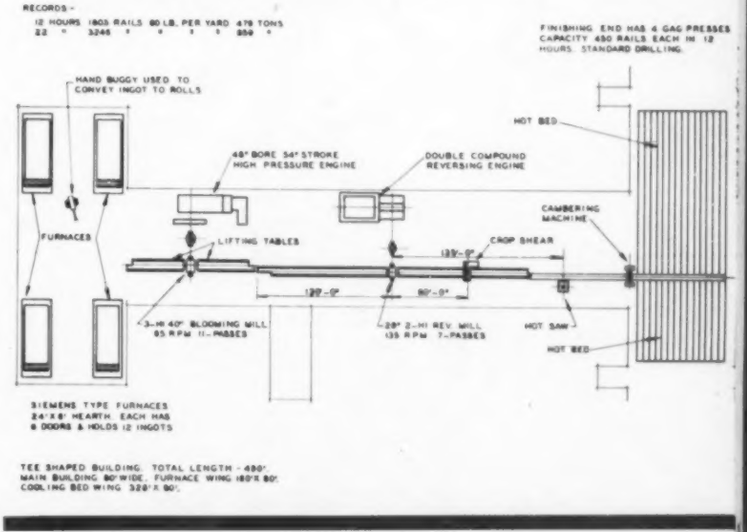
the rolling was completed in seven passes, two roughing and five finishing.

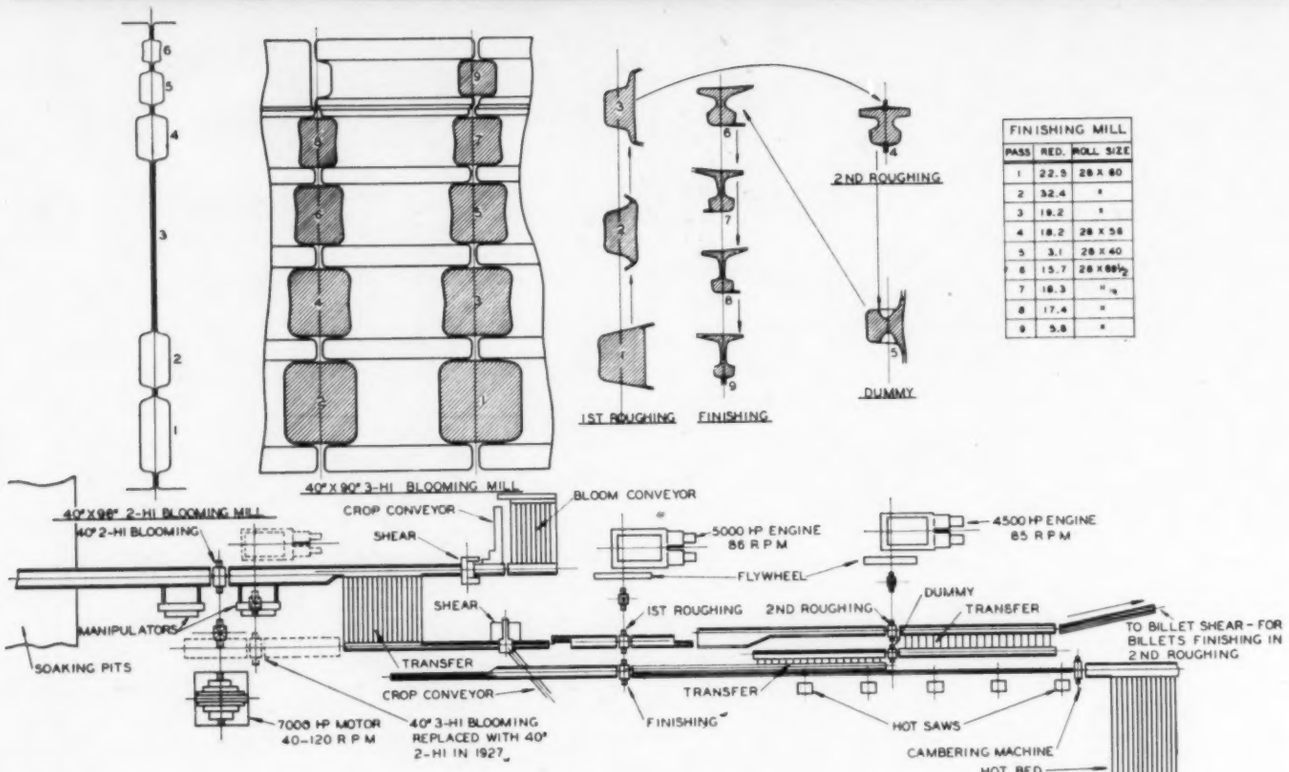
The finished rail was then run down to a single hot saw equipped with movable gauges for regulating the sawing to the required rail length. After sawing, the rail passed through a cambering machine and then to the cooling beds. Straightening of the rail was done in gag presses. A good turn of twelve hours work on the gags produced 470 gross tons of 60 pound straightened rails.

This mill later was completely rebuilt on a much more elaborate plan as shown in Drawing 12. The original blooming mill was three-high, but in 1927 it was changed to a two-high reversing mill. The finishing mill, as it was reconstructed and as it is at the present, consists of four three-high roll stands. The roughing and finishing stands are driven by one engine, and the second roughing and dummy are driven by another. The blooming mill produces a bloom approximately 8 in. × 8 in., and the finishing mill converts the bloom to a rail in nine passes direct from the ingot. The finishing mill passes are arranged three in the roughing, one in the second roughing, one in the dummy stand, and four in the finishing. The finishing stand accommodates as many as three rails at the same time. With this pass arrangement and with the three-high bloomer, a record tonnage of 1730 gross tons of 90 pound rails was rolled in a twelve hour turn with approximately one hour of delay.

Among the many rail mills one had a rather unique roughing stand. This mill operated on rails about the year 1906, as shown in Drawing 13. The roughing consisted of three stands of 26 in. diameter rolls in tandem, placed so that stands No. 1 rolled in the forward direction, stand No. 2 rolled backward, and stand No. 3 rolled in the forward direction the same as stand No. 1. In operation, the bloom delivered from the 40 in. blooming mill was entered in stand No. 1. It passed

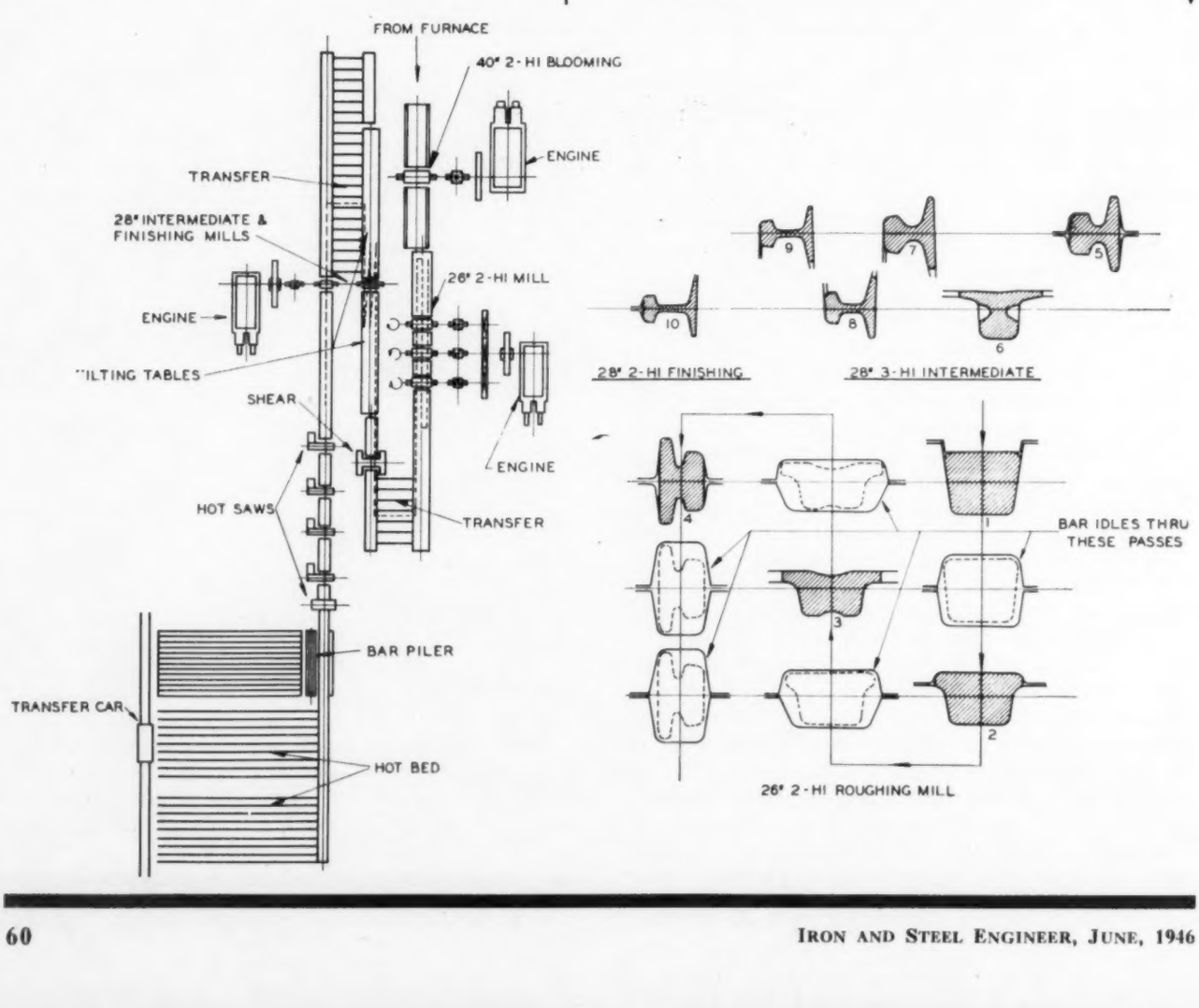
Drawing 11 — South Chicago Works of the North Chicago Rolling Mill Company in 1881.


RECORDS:-
12 HOURS 1803 RAILS 60 LB. PER YARD 470 TONS
22 " 3248 " " " " " 850 "
FINISHING END HAS 4 GAG PRESSES CAPACITY 450 RAILS EACH IN 12 HOURS. STANDARD DRILLING.
HAND BUGGY USED TO CONVEY INGOT TO ROLLS
HOT BED
40" BORE 54" STROKE HIGH PRESSURE ENGINE
DOUBLE COMPOUND REVERSING ENGINE
CAMBERING MACHINE
FURNACES
LIFTING TABLES
CROP SHEAR
139'-0"
129'-0"
90'-0"
3-HI 40" BLOOMING MILL 85 R.P.M. 11-PASSES
28" 2-HI REV. MILL 135 R.P.M. 7-PASSES
HOT SAW
HOT BED
SIEMENS TYPE FURNACES 24'X8' HEARTH. EACH HAS 6 DOORS & HOLDS 12 INGOTS
TEE SHAPED BUILDING. TOTAL LENGTH - 480' MAIN BUILDING 80' WIDE. FURNACE WING 180'X 80' COOLING BED WING 320'X 80'.



Drawing 12 — Cross country type of rail mill as of 1902.

Drawing 13 — Early type rail mill with special roughing stands.



through stand No. 2 in a sort of enlarged dummy pass and entered the second live pass of stand No. 3. The rail was then transferred sideways and put through a dummy pass in stand No. 3, a live pass in stand No. 2 and another dummy pass in stand No. 1. Again the rail was transferred sideways and entered into the fourth live pass in stand No. 1 after which it was dummied through stands No. 2 and No. 3 and passed on to the finishing train of the mill. The finishing stands consisted of one three-high stand and one two-high stand of rolls. There were five passes in the three-high set and one pass in the two-high set. The mill was located in the Youngstown district and is now obsolete.

The stock used for rolling the larger rails in this country up to the year 1865 was wrought iron piles or hammered or rolled blooms of puddle iron. In rolling tee rails from piles considerable difficulty was experienced by the pile not being sufficiently welded before starting to roll in the flange passes. The iron would often split but in spite of these difficulties, large quantities of iron tee rails were rolled before the advent of the steel rail.

As previously stated, in 1865 a few small bessemer steel ingots were rolled into 50 pound rails at the works of the North Chicago Rolling Mill Company on the north side of Chicago as an experiment. Roll passes designed for iron were used in this experiment and the rolling was successful. This was the beginning of the bessemer rail in this country. Drawing 14, Figure 1 shows the 50 pound rail rolled at North Chicago in 1865. Note the contrast between this rail and the modern 152 pound rail shown in Figure 2 on Drawing 14.

In 1867 the first bessemer steel rails made to order for a railroad were rolled on the 21 in. three-high rail mill of the Cambria Iron Company of Johnstown, Pennsylvania.

From this date progress was rapid. Steel rails were in great demand and several new mills were built to roll them. The iron rails, however, were not completely superseded until much later. Many of these mills have gone out of existence and some were converted to roll other products. At the present time there are only a few mills rolling the larger sizes of rails.

PRESENT TYPES OF RAIL MILLS

Eight of the eleven mills on the North American continent rolling large tee rails are classed strictly as rail mills, although some of these are now rolling billets and rounds as well as rails. The other mills roll structural and other shapes as part of their product. Some mills roll direct from the ingot while others reheat the bloom.

These mills are far from being standardized in layout. Some have a large number of stands, others only a few, some are two-high throughout while others are three-high.

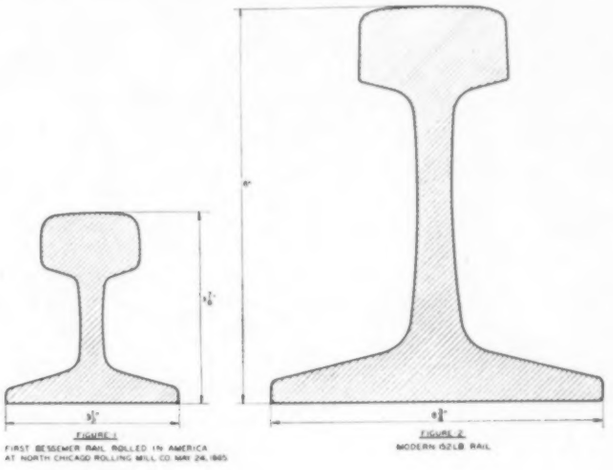
Drawing 15 illustrates a three-stand 28 in. mill served by a 35 in. two-high reversing blooming mill. In the rail finishing mill the rails are first rolled with six passes in the three-high roughing stand, followed by four passes in the three-high intermediate stand, and finally one pass in the two-high finishing stand, eleven passes in all. A continuous furnace is used for reheating the rails for rolling.

Drawing 16 shows a mill which is a combined rail and structural mill. It has a two-high reversing blooming mill, and between the blooming and the rail-structural mill are batch type reheating furnaces. The mill consists of three roll stands in line, driven by one motor. The first two stands are three-high and the finishing stand is two-high.

Drawing 17 shows a rail mill which has three 27 in. stands served by one continuous reheating furnace. The eleven passes in this mill are as follows: six in the three-high roughing stand, four in the three-high intermediate stand, and one in the two-high finishing stand.

The blooms for the mill are furnished by a 40 in. or a 46 in. two-high blooming mill.

An early type rail mill remodeled in later years is shown on Drawing 18. This mill, as it now stands, has a 36 in. two-high reversing blooming mill rolling an $8\frac{5}{8}$ in. $\times$ 9 in. bloom. The first three-high set of the rail mill has five passes. The stand is driven independently of the other stands. The second three-high stand has four passes and is also independently driven, and the final



Drawing 14 — Comparison of old with modern rail sections.

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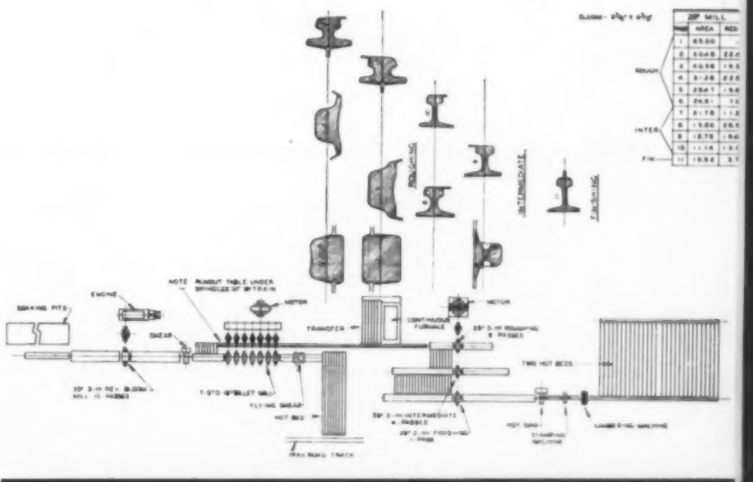
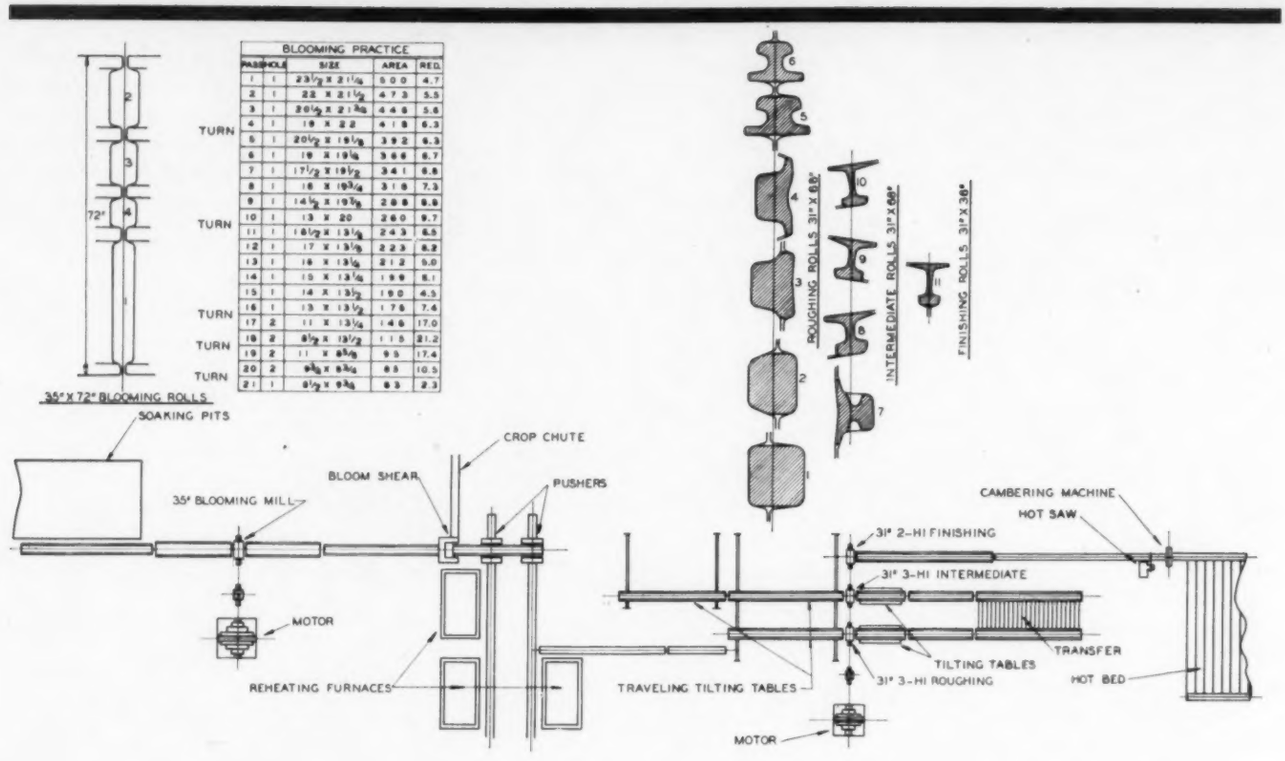
Drawing 15 — 28 in. 3-stand rail mill.





Drawing 16 — Combined rail and structural mill.

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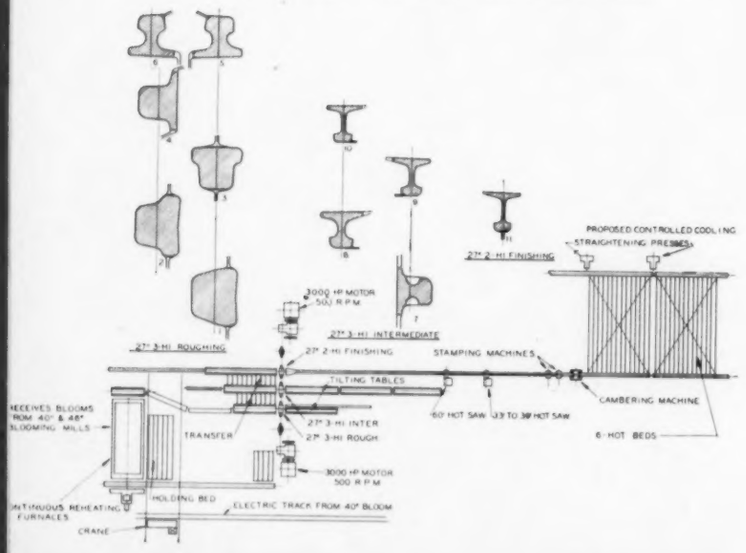
Drawing 17 — 27 in. 3-stand rail mill.



stand, the finishing, has one pass and is likewise driven independently.

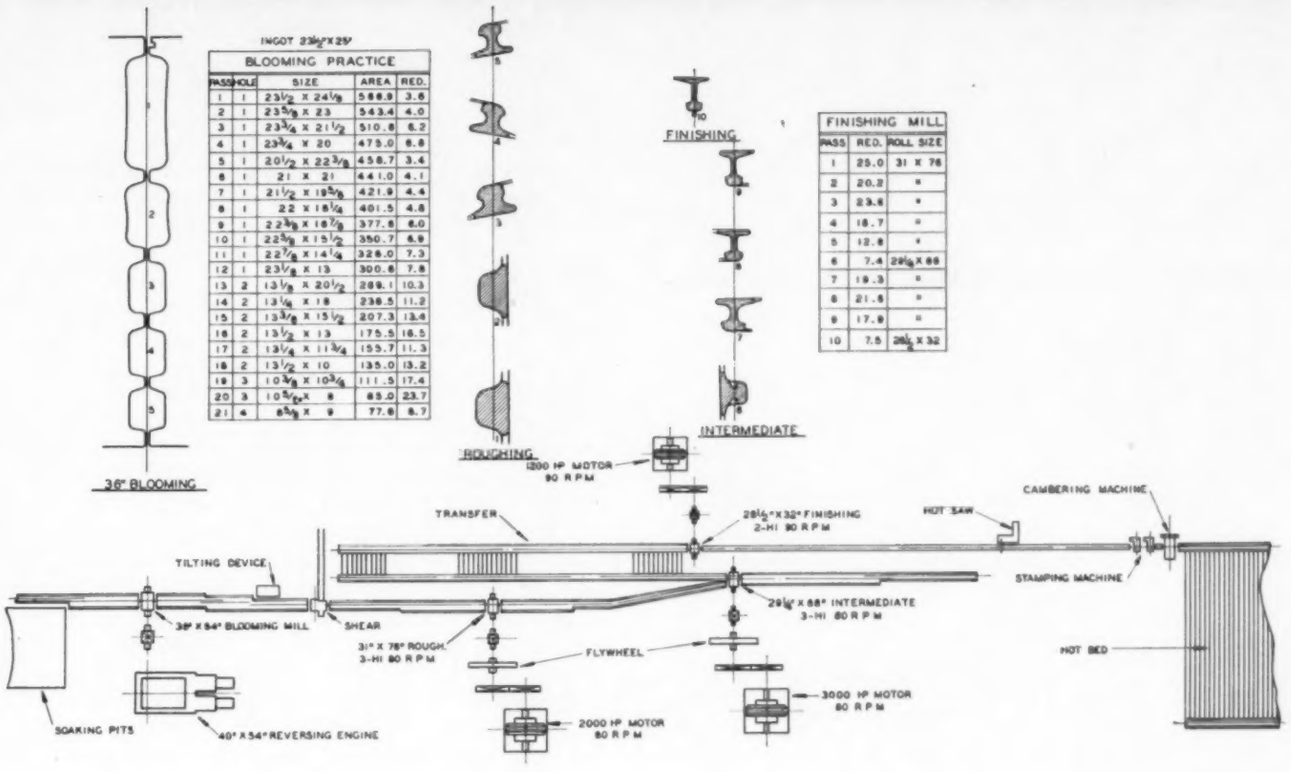
Drawing 19 illustrates a mill which has a 40 in. two-high reversing blooming mill and a four-stand rail mill. The first stand of the rail mill is a 35 in. two-high reversing mill. Straight ahead of this is a two-stand 28 in. mill, three-high. Ahead of the second stand of this train is a two-high 28 in. stand. The passes for standard rails are divided; five in the first stand, three in the second stand and two in the third stand. The two-high finishing stand is used only for street car rails.

A rail mill which has two-high reversing stands throughout is illustrated on Drawing 20. The ingots are rolled on a 44 in. blooming mill and the blooms are reheated in flat batch type furnaces and rolled on an independently driven roughing mill which is ahead of the two-stand finishing mill. The finishing mill is driven by a reversing motor.

Drawing 21 shows a mill which consists of a 44 in. two-high reversing blooming mill and a five-stand rail mill, the first stands of which are two in number, two-high and driven by a reversing engine. The second stand of this mill is used as a billet stand only. The second train of rolls consists of three stands; the first and second stand three-high and the third stand, (the finishing two-high.) Passes are divided, five in the 34 in. mill, two in the 28 in. roughing, two in the 28 in. intermediate, and one in the 28 in. finishing mill. This mill has no reheating furnaces and rolls direct from the ingot.

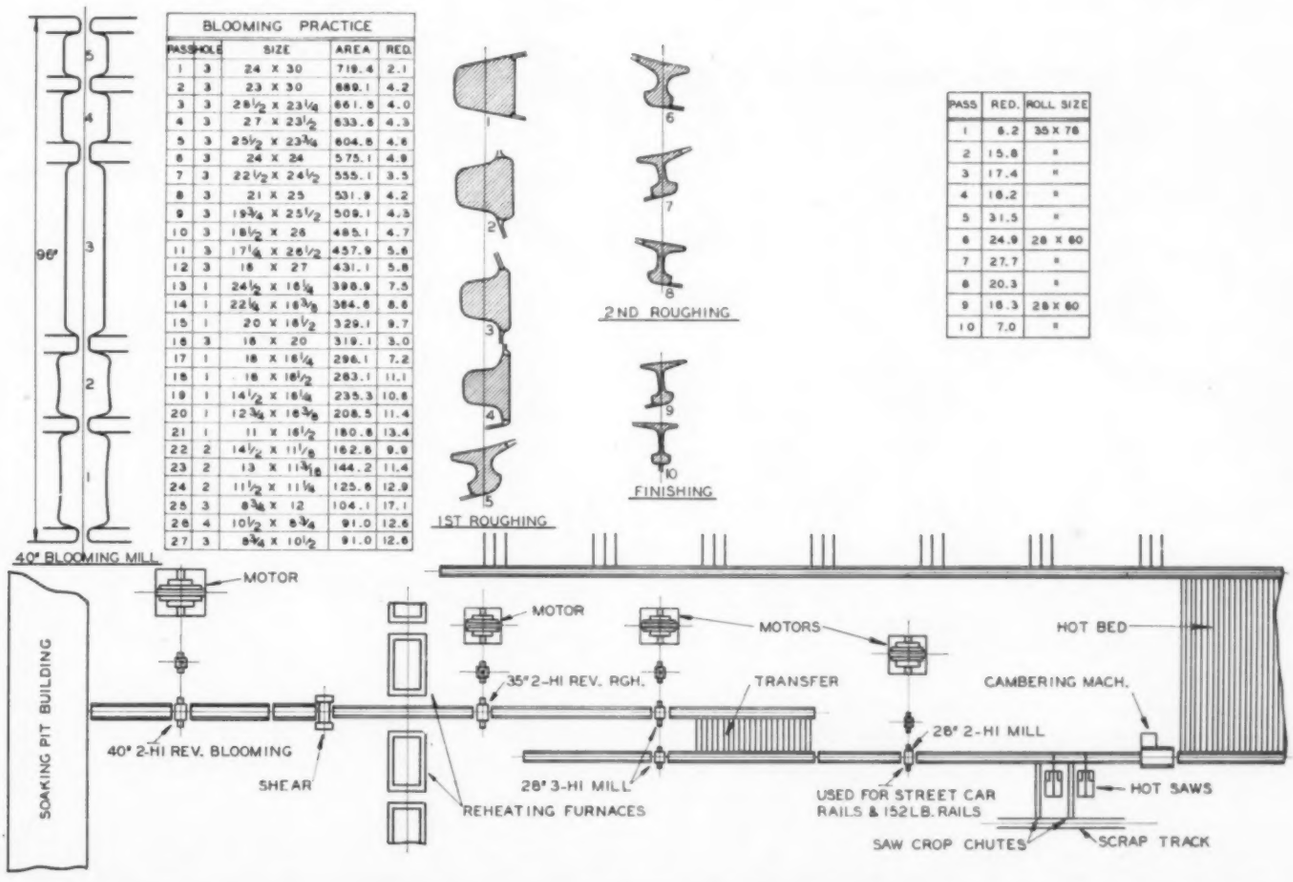
Drawing 22 illustrates a mill built to roll structural material and rails. In this design the 40 in. two-high reversing mill rolls the blooms which are delivered in the rear of the continuous furnaces while still hot. The furnaces feed the heated blooms directly into a two-high reversing roughing mill. Directly ahead is the three-high and two-high 28 in. finishing mill which receives the partly shaped rail from the 32 in. mill and finishes it in six passes. The rail then goes to the saws and cambering machine and on to the hot beds and slow cooling boxes.

One of the largest mills in the country is shown on Drawing 23. The mill has a 48 in. two-stand, two-high tandem bloomer with two passes in each stand. After the ingot has passed through once, it is returned to the first stand by a run-around turn table for the second pass. After passing through the stands twice, the piece goes on to a three-high 40 in. blooming mill, where it is given seven passes. After being sheared into bloom



Drawing 18 — Three-stand rail mill with 3-high reversing blooming mill. ↑

Drawing 19 — Tandem rail mill with 2-high blooming mill. ↓

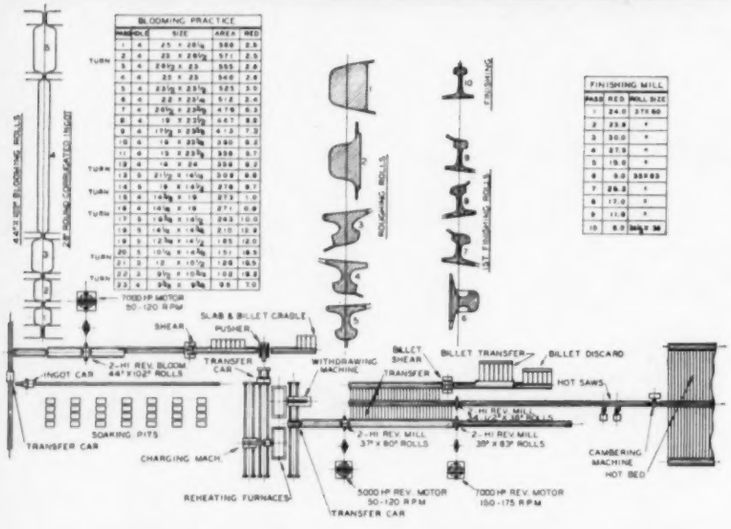


lengths and reheated, the blooms go on to a four-stand rail finishing mill, the first part of which consists of two engine driven three-high stands. The bar is given five passes in the first set of rolls and four passes in the second set and then moves straight forward to a three-high stand driven by its own engine, where it is given three additional passes. From this stand, the rail moves on to the two-high finishing mill for the final pass. There are thirteen passes from the bloom to the finished rail.

The layout of the largest rail mill in this country is somewhat similar to the cross-country type and is shown in Drawing 24. This mill starts with four tandem stands of 40 in. two-high rolls. In these stands, the ingot is given one pass per stand, and is turned after each pass. The passes are of diamond, diamond square and box pass design. After the initial passes there is a three-high 40 in. mill with five box passes, the final pass being slightly shaped. Following this three-high blooming stand is the bloom shear and then the cross-country arrangement of seven stands of rolls arranged in two groups of three stands each and one separate stand. The separate stand is marked 13 on the drawing. The leader stand has a vertical roll working on the head of the rail and the finishing stand has one for the base of the rail.

In the southern part of the continent is a combined rail and structural mill, shown in Drawing 25. The primary mill in the combination is a 40 in. two-high reversing blooming mill, which supplies blooms for a 32 in. two-high reversing roughing mill. Blooms are reheated in two batch type furnaces for the roughing and finishing trains. The finishing mill consists of three stands of 28 in. three-high rolls. The mill has traveling tables and the pieces from the 32 in. mill may be delivered to and rolled in one of the three stands or a combination of all three before passing on to the hotbed.

In Europe, the specialty mill is not a common type. Most European mills are built to roll a large variety of sections. One such interesting layout shown in Drawing 26 is in Hagendingen, Germany. This mill was in German hands from 1912 to 1918, operated by the French from 1918 to 1939, and returned to the Germans in 1939. This rather unique layout consists of four stands of 37½ in. diameter and two stands of 33½ in. diameter two-high reversing rolls in line driven by two reversing motors. One set incorporates a universal



Drawing 20 — 2-high rail mill with 2-high reversing blooming mill.

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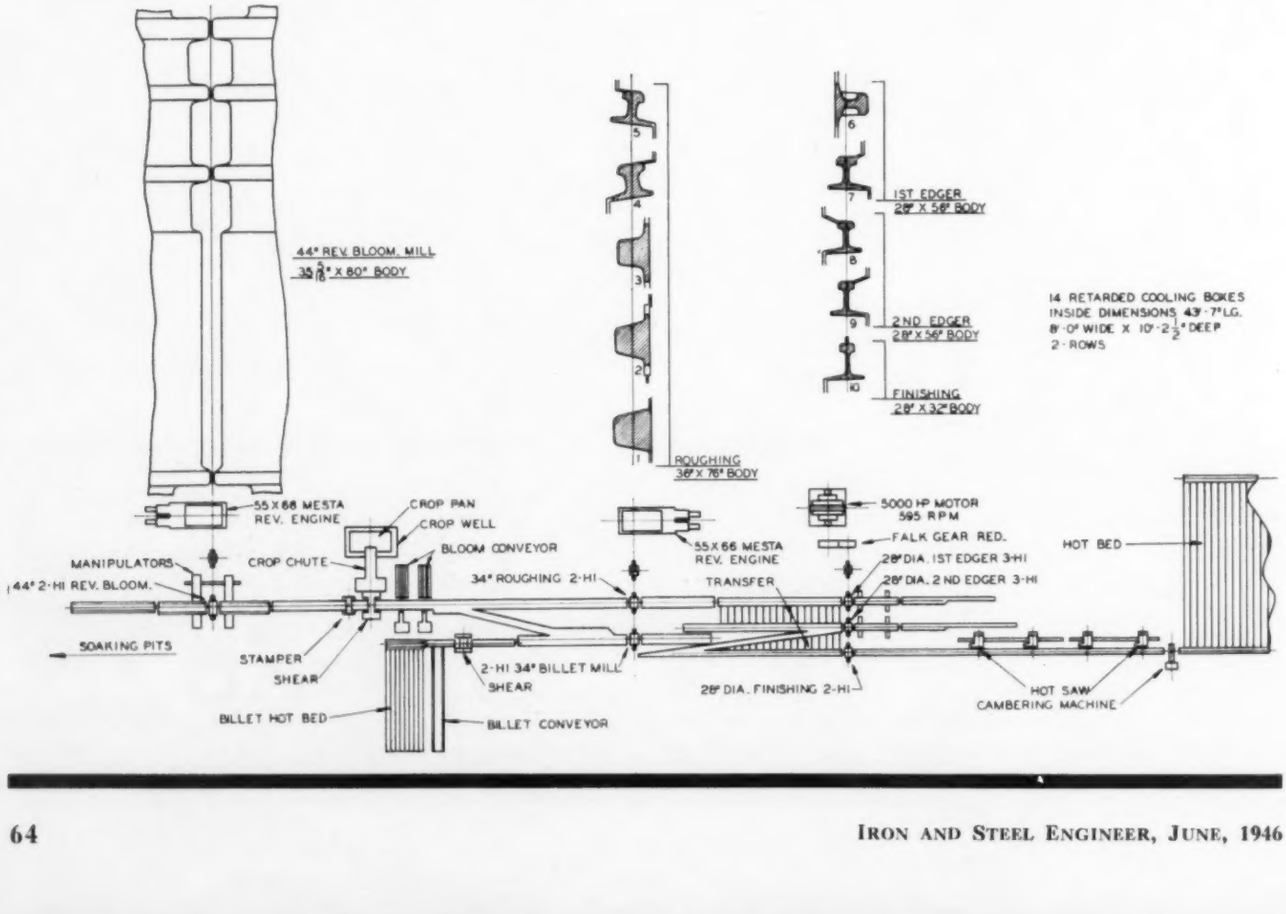
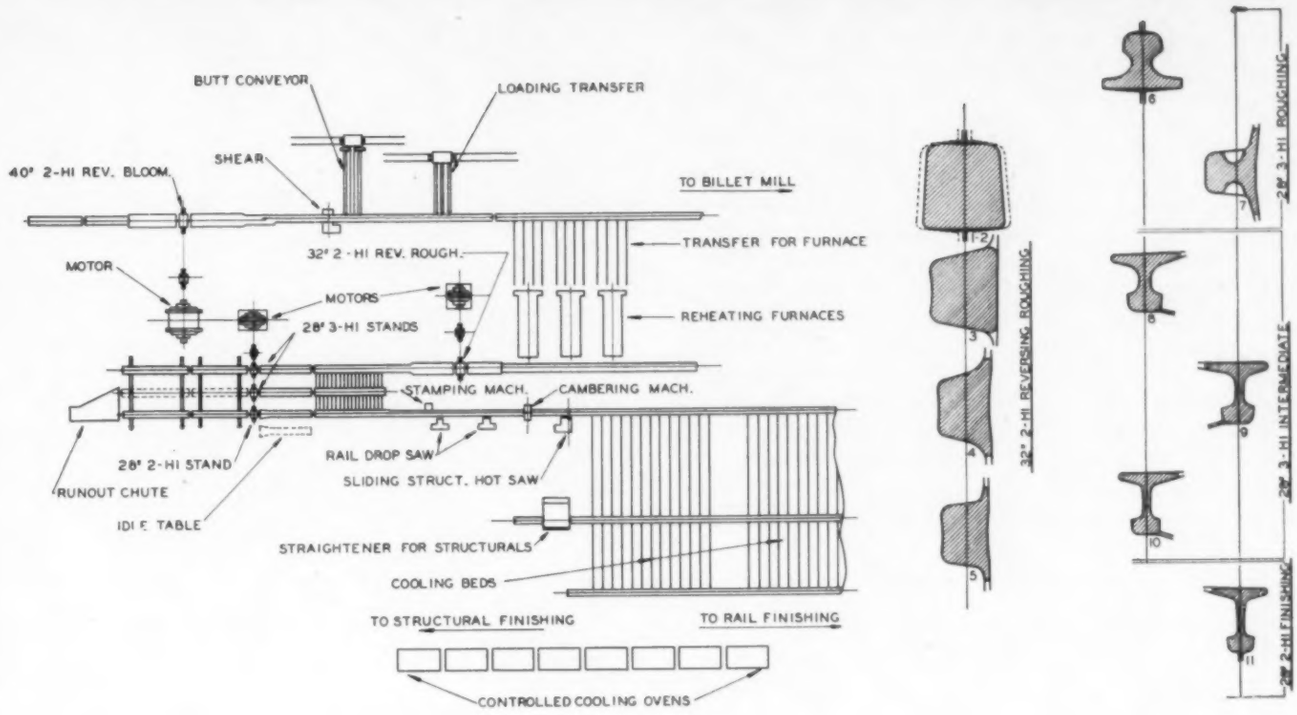
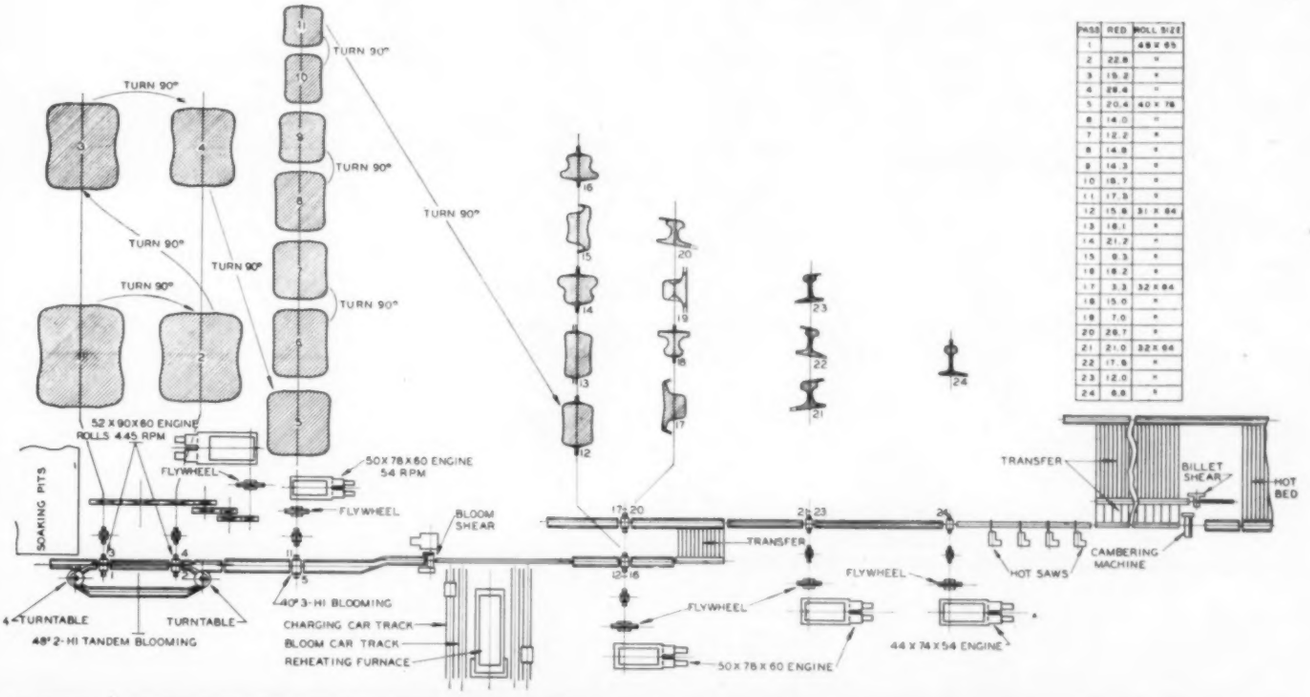
Drawing 21 — 28 in. five-stand rail mill.





Drawing 22 — 28 in. rail and structural mill.

Drawing 23 — Four-stand rail mill with 3-stand, 3-high blooming mill.



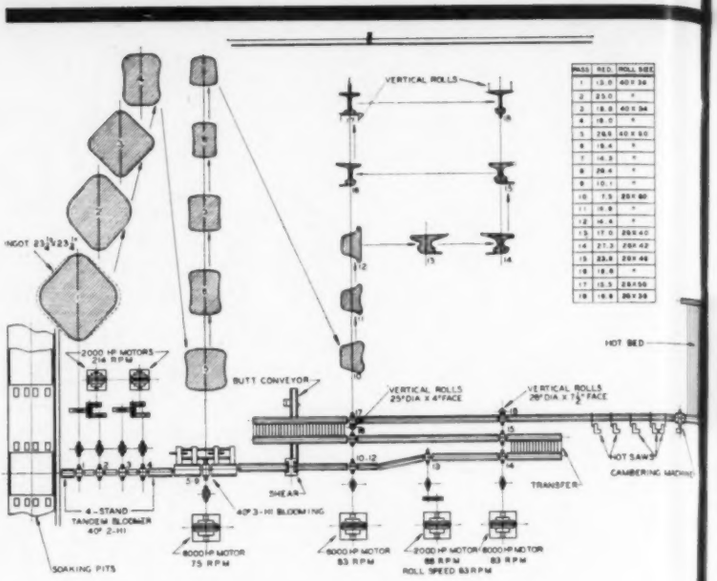
PASS	RED	ROLL SIZE
1		48 X 65
2	22.8	"
3	15.2	"
4	29.4	"
5	20.4	40 X 78
6	14.0	"
7	12.2	"
8	14.8	"
9	14.3	"
10	18.7	"
11	17.5	"
12	15.6	31 X 64
13	18.1	"
14	21.2	"
15	9.3	"
16	18.2	"
17	3.3	32 X 64
18	15.0	"
19	7.0	"
20	28.7	"
21	21.0	32 X 64
22	17.6	"
23	12.0	"
24	8.0	"

screwdown. The number of stands driven by each motor varies according to the sections being rolled. In addition to rails, the mill rolls beams, channels, angles, flats, railroad ties, squares and rounds. Two or more sections are rolled at the same time direct from the ingot without reheating. It was on this mill that Courtehoux first rolled rails by his patented design from a slit slab, and it is said that the famous German roll designer, Dehez, designed the rail passes that were used by Courtehoux in this method. In Dehez's unique pass design for rail rolling, a slab produced in the blooming mill is slit in two passes in the 37½ in. diameter screwdown set. After slitting, each of the resulting blooms is rolled directly into a rail in seven passes.

The object of this style of working, patented by Jules Courtehoux, is not only to get greater tonnage from the blooming mill, but also to place the center of the slab, which reputedly has a poorer grain structure than

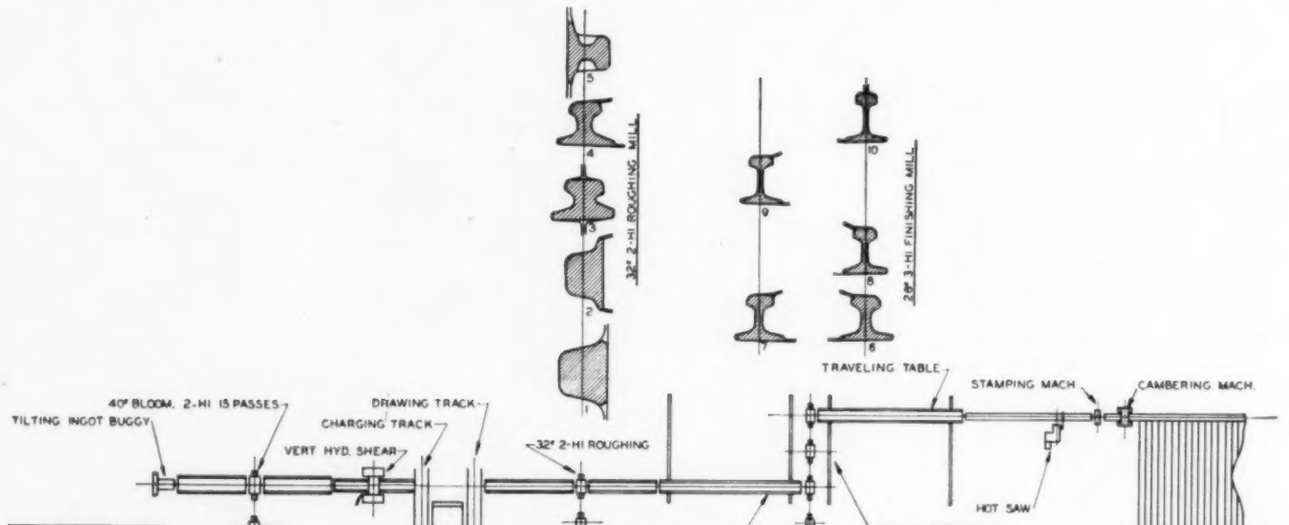
the outside, into the base of the rail. The flexibility of the mill is remarkable. It is never completely down for roll changes, since some stands may continue to operate during changes. The rails from this mill are hot sawed to length after leaving the finishing pass on their way to the hot beds.

Drawing 27, an example of an English type mill located in northeastern England, consists of a 42 in. two-high reversing blooming mill, or as the English say, cogging mill. This mill rolls the blooms for a two-stand 34 in. two-high reversing section and rail mill. Each stand of the 34 in. mill is operated by a reversing engine. The stock for the mill is reheated by two flat hearth type furnaces provided with charging and drawing machines. The mill rolls rails of all sizes including tram or street car rails. It is provided with hot saws, a cambering machine and gags for straightening rail. This mill is typical of the English rolling mill in that it is not built for a large tonnage of any particular size, but rather for a large variety of comparatively small orders.



Drawing 24 — Largest rail mill in the United States.

Drawing 25 — Combination rail and structural mill.

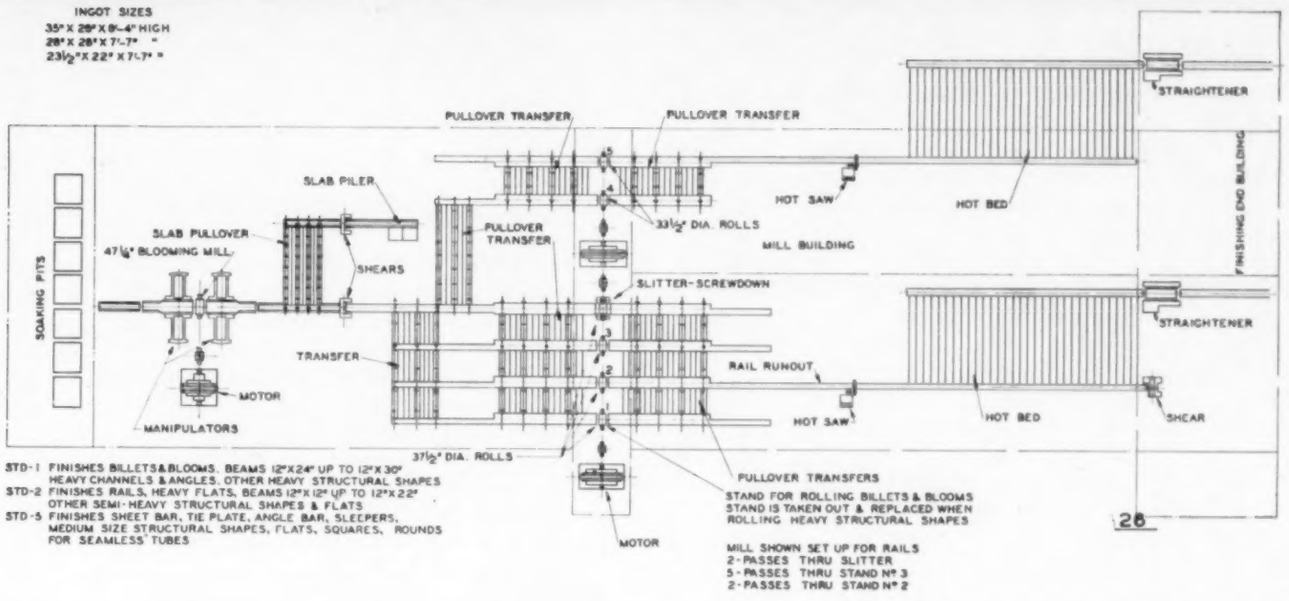


RAIL STRAIGHTENING

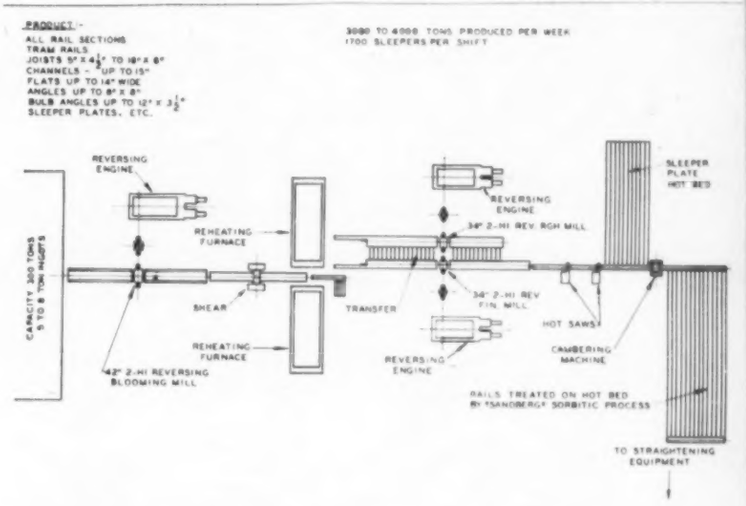
When a rail leaves the finishing stand of a mill, it moves along the run-out table which, in most cases, is grooved for the rail flange, allowing the rail to lie flat on the table. The rail is then sawed to length by the hot saws. After being sawed, the rail is passed through a cambering machine in which it is cambered to the base side, as shown in Figure 1, Drawing 28. The reason for this procedure is that the rail when cold will be cambered toward the head to take care of the greater shrinkage in the head of the rail. The head of the rail finishes at a much higher temperature than the flanges because of the greater thickness of the head and consequently, shrinks more than the flanges in cooling. The cambering of the rail by the machine stretches and lengthens the head of the rail and cambers it toward the base so that the final shrinkage pulls the rail straight. Should the rail be allowed to cool without the cambering operation, it would be curved considerably and the straightening operation made more difficult.

It is the custom in this country to straighten rails in a gag press, as shown in Figure 2. In England and Germany roller straighteners are used extensively. Perhaps 10 per cent of the straightening is done in gags to straighten the rails near the ends where the roller straightener is not effective. If a good job of cambering is done, very little remains for the gag press to do.

Prior to the war, a number of machine builders in Germany made special roller straighteners for rails, a number of which are used in England. A popular ma-



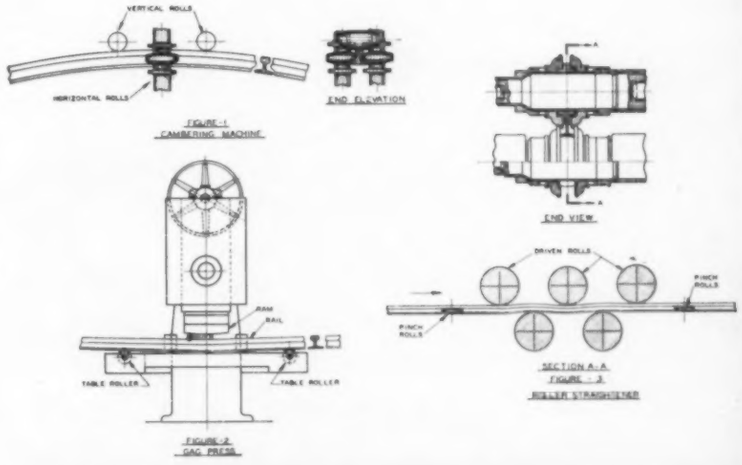
Drawing 26 — Rail, billet and structural mill in August Thyssen plant, Hagendingen, Germany.



Drawing 27 — English rail mill, Bolckow-Vaughn & Company, 1925.

▲

Drawing 28 — Straightening machines.



FURNACES AND CHARGING AND DRAWING MECHANISMS

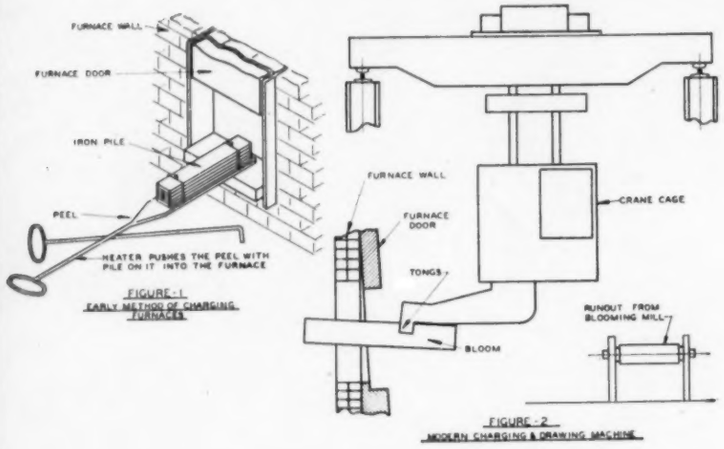
chine, shown in Figure 3, had five rolls, three on the top and two on the bottom. Contrary to American practice, the top rolls are driven. It will be noted that the rails are mostly straightened base down and head up, and this is considered to be preferable to the horizontal position. The straightening rolls are made so that the grooves in which the rails ride can be adjusted in size to fit the various sizes.

In the early days of rolling, the reheating furnaces were of simple construction. When compared with modern machinery, it is easy to observe the progress which has been made. The simplest equipment for charging was a manually operated iron peel shown in Drawing 29, Figure 1. One end of the peel was supported on the door frame of the furnace and the other end was held by the heater. The pile was laid on the peel immediately in front of the furnace door and then pushed into the furnace. The entire heat was charged in this manner. After the iron was heated to a welding temperature, the heater drew the piles to the furnace door by means of a hooked bar. The pile was then taken to the rolls by a pair of manually operated tongs suspended from a trolley.

In the beginning the heating furnaces were coal fired, but later gas firing became more popular. The bottoms were flat, slightly sloping, and the ingots, blooms or piles were laid directly on the sand bottom. The bottom was designed with a slope to permit the slag to run down to a hole provided for slag removal.

With the advent of the steel ingot or bloom, heavier and longer rails were rolled and, due to the increased weight, older methods of charging and drawing became

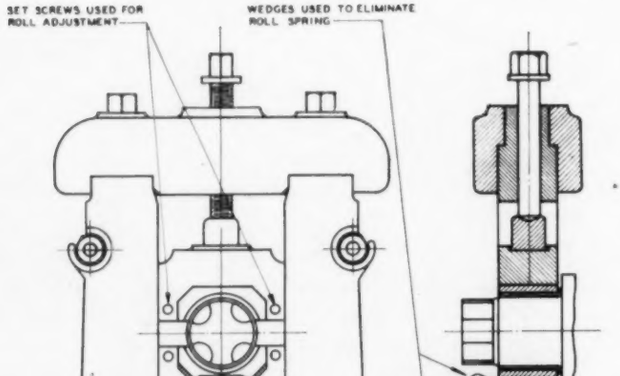
inadequate. An improvement resulted from the development of the hydraulically operated peel. The power operated peel received the ingot or bloom from a crane and pushed it into the furnace. The peel was then turned, allowing the ingot to fall onto the hearth. The peel was not used in drawing the charge. A hook attached to a chain was used for this purpose. The hook was fastened over the far end of the heated piece which was pulled forward through the door of the furnace onto a hand operated buggy.



Drawing 29 — Charging methods, old and new.

▲

Drawing 30 — Old style rail mill housing.



This machine was crude and only good for a limited tonnage. Figure 2 shows a modern machine for charging and drawing blooms which is provided with tongs to pick up the blooms from roller tables or cars, place them in position in the furnace, pick them up when heated and set them on the approach table to the mill.

CONTROLLED COOLING

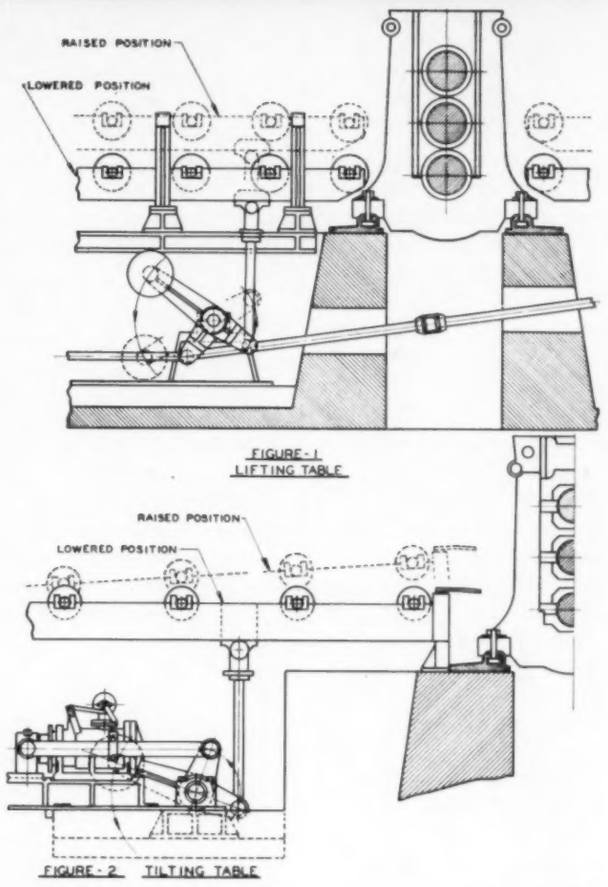
Before the advent of controlled cooling, finishing temperatures of rails were given considerable study and it was found that those finished at the lower temperatures had a smaller grain structure in the head and provided greater resistance to wear. On the other hand, the drafts necessary to roll rails required a ductile steel attained only by well heated ingots. One mill arranged a holding table in front of the finishing stand where rails were held for a time and thus finished at lower temperature. The one pass at the lower temperature, however, did not materially affect the grain structure and the practice was soon discontinued. The use of controlled cooling boxes was inaugurated to prevent shatter cracks, and to relieve strains. It also gives considerable grain refinement. Consequently the rail has greater resistance to wear even though rolled at a relatively high temperature. Most rail mills in the country today are equipped with controlled cooling boxes.

HOUSINGS

In general, rail mill housings are no different than structural mill housings, particularly if they are two-high. An exception to this is the case of a three-high finishing stand housing having four passes in the rolls and more than one bar in the stand at one time. The fact that two or more bars of varying temperatures are going through the rolls at the same time requires a very rigid housing with little or no spring in the rolls. Any noticeable spring would have its effect on the size of the finished rail and which hence would not conform to the templet. One of the older type mills, where there may be three rails in the finishing stand at one time, had a type of housing illustrated in Drawing 30. The vertical setting of the rolls in the housing was controlled by a top screw and wedges between the carriages. After setting the rolls and top screw, and pushing the wedges up tight, it was possible to eliminate most of the roll spring, and the three rails at varying temperatures were rolled to templet size at the same time in the finishing stand.

MILL TABLES

Mill tables are of the lifting or tilting type for three-high mills, as illustrated in Drawing 31. Three-high roughing mills of the older types had tables which were almost invariably of the lifting type, while those on the three-high intermediate and finishing stands were tilting. The cross-country two-high mill tables were, of course, stationary. Since there are a number of turns or manipulations to be made in the various rail passes, there are also a number of ingenious turning devices in use. Figure 1, Drawing 32, shows a turning device used



Drawing 31 — Lifting and tilting tables for three-high mills.

on lifting and tilting tables for turning up the bar for the first of the roughing passes. In this case the manipulating bars are fixed and the dropping table causes the bar to turn as it slides between them.

The bar from the so-called "hat" pass must be turned to enter the forming pass and a method of accomplishing this is shown in Figure 2. In this device the table rollers are grooved, causing the hat shaped bar to roll over and turn as indicated by the full and dotted lines on the drawing. The bar coming out of the forming pass falls over flat on the table, is lifted up, turned over, and deposited on a higher level table to enter the dummy pass by arms as shown in Figure 3 of the same drawing. After it is put through the dummy pass and has run out onto the back dummy table, it is pushed side-ways over the edge of the table onto a grooved table roller in position to enter the first edging pass in the finishing stand as shown in Figure 4.

Another device for turning the rail up on its base is shown in Figure 5. They are turned in this position for charging in the controlled cooling boxes which are a part of modern rail mill equipment.

There are many more interesting devices for turning and transferring rail bars but space prohibits describing them.

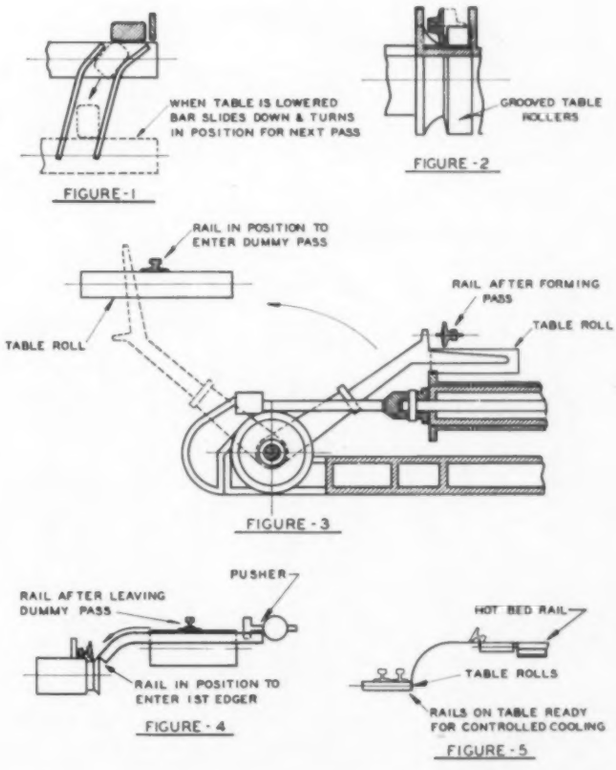
ROLLS FOR RAIL MILLS

Roll castings for rail mills fall into two general classifications, iron and steel. In the blooming mills the most generally used material is the steel alloy roll, varying in carbon content from 0.50 to 1.50 per cent, and either alloyed with chrome-nickel, chrome-nickel-molybdenum, or chrome-molybdenum. Of late years the chrome-molybdenum roll is most commonly used. As a general rule, roughing rolls are also of alloy steel, although there have been cases noted where some of the harder grades were too smooth for the early roughing passes. As a result, the rolls could not take sufficient bite. Intermediate rolls have in a number of cases been made of iron alloy, although in other cases hard alloy steel has been used.

The finishing rolls and leader rolls present the greatest difficulty for the roll maker. Most leader roll designs for rails have the passes set in the rolls so that the sides of the base and head are covered by roll collars. The remaining portions are covered by the mating roll, shown in Drawing 33. There is considerable friction on the sides which in turn causes the pass to become wide from wear. The taper on the sides of the pass is not sufficient to allow the roll to be dressed back to size. Consequently, the pass becomes wider and soon is too wide for the finishing pass which does not wear to the same extent and this is indicated in Figure 2. Thus any roll material which minimizes leader pass wear is highly desirable. Special alloy grades of iron, or a very hard alloy steel, are used in most cases.

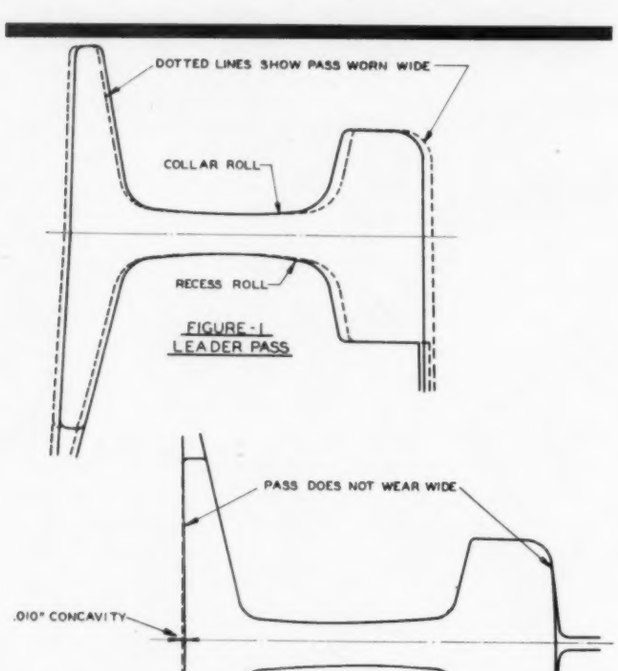
The finishing rolls for rails are required to be of hard, fine grained material, since a close tolerance must be maintained. It was customary in the former times to use chill rolls with the chill extending about three inches

Drawing 32 — Methods of turning and transferring rails.


WHEN TABLE IS LOWERED BAR SLIDES DOWN & TURNS IN POSITION FOR NEXT PASS
FIGURE - 1
GROOVED TABLE ROLLERS
FIGURE - 2
RAIL IN POSITION TO ENTER DUMMY PASS
RAIL AFTER FORMING PASS
TABLE ROLL
TABLE ROLL
FIGURE - 3
PUSHER
RAIL AFTER LEAVING DUMMY PASS
RAIL IN POSITION TO ENTER 1ST EDGER
FIGURE - 4
HOT BED RAIL
TABLE ROLLS
RAILS ON TABLE READY FOR CONTROLLED COOLING
FIGURE - 5

deep. This was a real problem, because the deep chill caused brittleness in the roll. While some of the chilled iron rolls are still used for finishing passes, they are being replaced by newer types of iron alloys. Drawing 34 shows some roll molds for rail mill rolls. The analyses for the rolls shown are as follows:

Figure 1 — Grain iron finisher, carbon 2.70 per cent, manganese 0.52 per cent, silicon 1.13 per cent, sulphur 0.110 per cent, phosphorous 0.185 per cent, chromium 1.00 per cent, and molybdenum 0.25 per cent.



Drawing 33 — Effect of wear on rail leader and finishing passes.

▲

Drawing 34 — Rail mill roll molds.

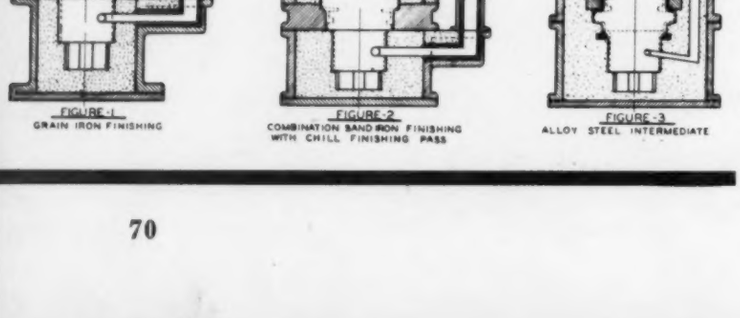


Figure 2 — Combination sand iron with chill finishing pass, carbon 2.51 per cent, manganese 0.52 per cent, silicon 1.04 per cent, sulphur 0.145 per cent, phosphorous 0.250 per cent, chromium 0.12 per cent, and nickel 0.25 per cent.

This type of roll is not used to any extent today.

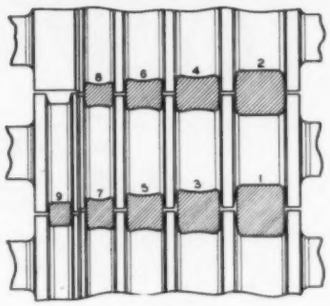
Figure 3 — Alloy steel intermediate, carbon 2.40 per cent, manganese 0.37 per cent, silicon 0.86 per cent, sulphur 0.060 per cent, phosphorous 0.107 per cent, chromium 0.95 per cent, and nickel 0.50 per cent. Roll is heat treated.

ROLL DESIGNING

As our subject is rail mills and rail mill roll designing, it might be of interest to review the history of rail roll designing. England had the first shape rolling mills and the mill manager, or owner who first rolled these rails, probably was the original designer. The job of turning the rolls was delegated to a roll lathe operator. As time went on and various sections were rolled, the roll turner acquired skill and gradually assumed control of the shaping of the passes and became a roll designer. At that time, the entire rolling process was kept a secret by the operator for fear of competition but, as roll designers became more skilled, they were hired away from their original employers by competitors who recognized their accomplishments and value, and thus the knowledge of roll design became more widely spread. That these men were skillful and resourceful in roll designing and roll turning is evident from the fact that Stevens was able to have an entirely new and radically different shaped rail rolled successfully in Great Britain as early as 1831.

The English tried to keep their successful operations a secret but history records that one Eberhard Hoesh of Duren traveled to England to study the puddling and rolling practice. During the period when Germany and Belgium were trying to improve rail rolling in their respective countries, this man managed to smuggle himself into the big Welsh Dowlais plant at night to watch the work. He afterwards brought the British engineer Dobbs to Germany to introduce the English technique. In 1838, after importing engineers, workmen and roll turners, who were experienced in roll design, Hoesh started to roll rails. Previously, however, several Belgian mills had been built and operated by Englishmen. One of the noted Belgian plants was at Seriang, built and operated by John Cockerill, an Englishman.

Many regard the basis of roll designing as a secret kept by the designers and rarely divulged. Nothing could be further from the truth. Roll designing is an art, not a science. It does not consist of formulas which can be learned and applied. The foremost principle that governs roll designing is the fact that as steel is reduced in area, it elongates and spreads under rolling pressure. The judgment of the roll designer, which is acquired by long experience, must be exercised in directing the flow of metal into the desired shapes. Through long experience, which is valueless unless supplemented by intensive, intelligent study, the designer acquires an intuitive ability in design. This intuition is a quality which cannot be transferred to others. Possession of data on sections which have been rolled is valuable but only as a

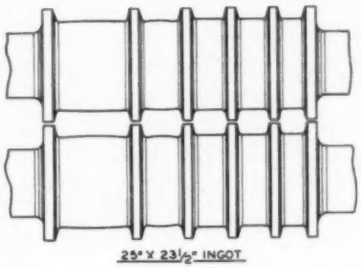


DRAFT IN INCHES

	ORIGINAL		REVISED	
1	3 1/16"		1 3/8"	
2	2 1/16"	TURN	1 15/16"	TURN
3	2 1/16"		1 3/8"	
4	2 1/16"	TURN	1 7/8"	TURN
5	2 1/16"		3 1/8"	
6	2 1/8"	TURN	2 3/16"	TURN
7	2 1/8"		3 5/16"	
8	1 7/8"		2 1/16"	
9	1 1/16"	TURN	2 3/16"	TURN

18" X 19 1/2" INGOT

FIGURE - 1
40" 3-HI RAIL BLOOMER



25" X 23 1/2" INGOT

FIGURE - 2
36" 2-HI RAIL BLOOMER

BLOOM. PRACTICE

Nº	SIZE	DRAFT
1	23 1/2 X 24 1/8	7/8
2	23 5/8 X 23	1 1/8
3	23 3/4 X 21 1/2	1 1/2
4	23 3/8 X 20	1 1/2
5	20 1/2 X 22 3/8	1 7/8
6	21 X 21	1 3/8
7	21 1/2 X 19 5/8	1 3/8
8	22 X 18 1/4	1 3/8
9	22 3/8 X 16 7/8	1 3/8
10	22 5/8 X 15 1/2	1 3/8
11	22 7/8 X 14 1/8	1 1/4
12	23 1/8 X 13	1 1/4
13	13 1/8 X 20 1/2	2 5/8
14	13 1/4 X 18	2 1/2
15	13 3/8 X 15 1/2	2 1/2
16	13 1/2 X 13	2 1/2
17	13 1/4 X 11 3/8	1 3/4
18	13 1/2 X 10	1 3/4
19	10 3/8 X 10 3/8	2 3/4
20	10 5/8 X 8	2 3/4
21	8 5/8 X 9	2

Drawing 35 — Comparison of two-high and three-high rail bloomers.

record of what has been done in the past. The true roll designer does not copy another's designs, but is always busy devising newer and better designs for each new section to be rolled. A mill fully adequate for producing a section does not tax the roll designer's ingenuity to the fullest; it is in the mill which is not fully adequate for the section to be rolled that the full skill of the roll designer must be exercised. Few realize the time and study needed, with limited opportunities available to acquire the necessary qualifications to become proficient in designing rolls for the various types of sections.

The art of rail roll designing has now been practiced for nearly one hundred and fifty years. Great Britain must be given credit for pioneering this field. Germany, France and Belgium were also early contributors to the development of roll design. Dehez, a German roll designer who died in 1920, devoted most of his life to rolling mill problems and left some notable rail and shape roll designs. These have been of special interest to students of this art.

Because of the tremendous demand for rails in America during the period when railroads were being built, rail roll design received much study. During this period much was learned of rail rolling practices and in consequence of this extensive study and experience which has been well applied, rails are rolled here to closer tolerance, and perhaps of better quality than in any other country.

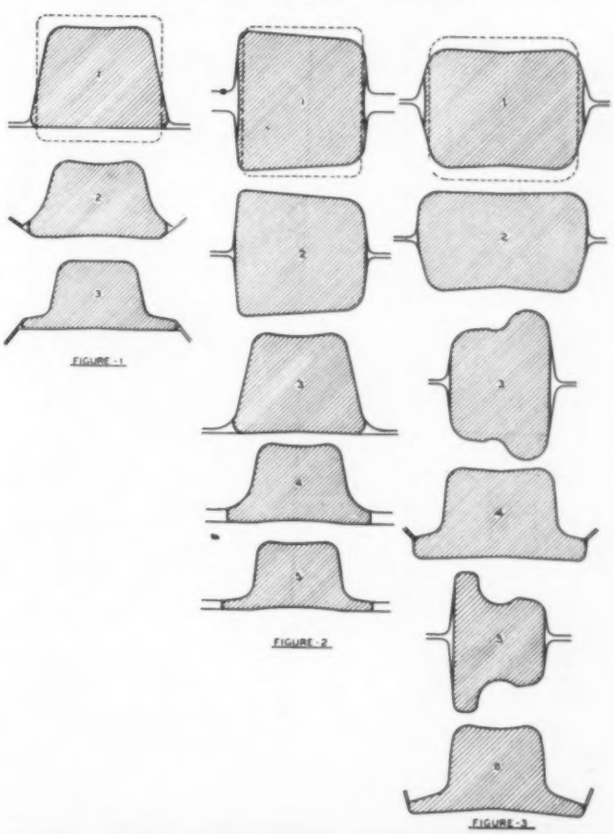
Since a rail is an unequal section it would be desirable to have proportionate reductions in all the parts of the rail, that is, head, web and base. The head being an approximate square retains the heat much longer than the comparatively thin web and base and consequently finishes at a higher temperature.

It is well known that rolling at the lower temperatures, within certain degrees, improves the quality and strength of the steel. In order to get proportionate reductions of all parts of the rail it would be necessary to start with a rail shaped ingot. In the rolling of large beams, a beam shaped ingot is used and this gives fairly proportionate reductions to web and flange. In the case of the rail, the types of mills used make it practically impossible to have a rail shaped ingot, so that rails are all made from a rectangular ingot.

It is obvious that proportionate drafts and elongations are not possible in rolling rails. Although it is desirable to give the head of the rail more work in rolling to produce a denser structure, and consequently, a better wearing surface, this is impracticable. The value of the extra draft on the head has long been recognized and many years ago a roll design was used in England which consisted of two horizontal rolls and one vertical roll. The horizontal rolls worked every part of the rail, except the top of the head, which was worked by the vertical roll. One modern rail mill has this feature on the leader pass.

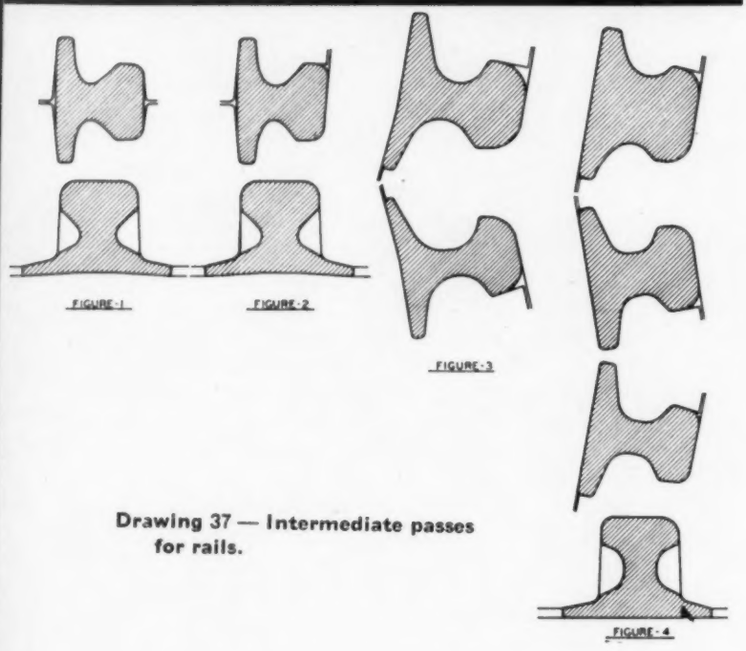
In the rail mills on the North American continent, while there is no great difference in the formation of passes, there are some differences in the number of passes used, and some variation in shapes, but no radical difference in design.

Drawing 36 — First shaping pass designs for rails.



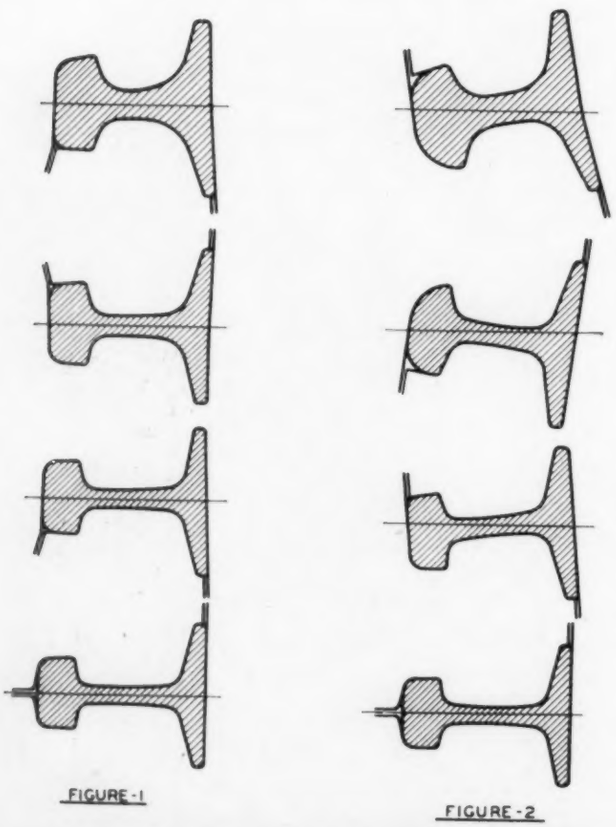
Several different methods are used in rail roll design on the continent. Some interesting comparisons of continental rail roll design with those in America are possible. A few of these designs will be shown later in the paper.

The type of mill has a direct influence on the roll design which may be used for rails. The arrangement of the roll stands and the design of the mill tables may be a factor in determining the roll design used.



Drawing 37 — Intermediate passes for rails.

Drawing 38 — Finishing passes for rails.



RAIL BLOOMING

After the three-high mill was introduced, the early rail mills in this country had three-high blooming rolls.

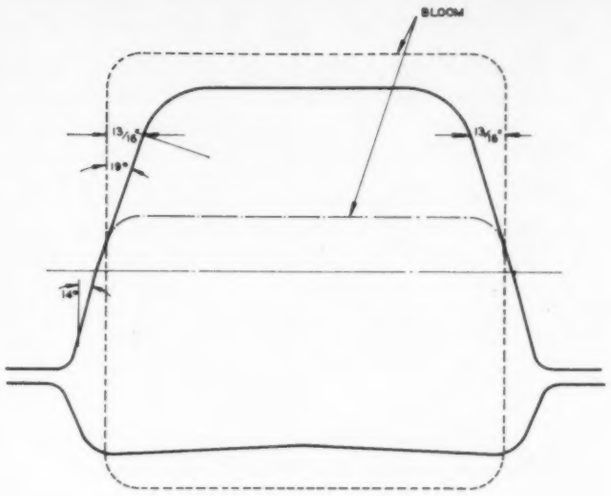
At first the ingots were small. The rail mill at Cambria used an 8½ in. × 8½ in. ingot in 1867. As rails of greater length, and weight were rolled. the ingots were increased in size. One mill, which started with a 14 in. ingot, gradually arrived at an 18 in. × 19½ in. ingot about 1900. This 18 in. × 19½ in. ingot was rolled to blooms approximately 8 in. × 8 in. in nine passes. The rolls were ragged more than usual for the amount of draft in these passes. It was on this same mill that an experiment was conducted to find out whether or not heavy drafts in the first passes were detrimental to the steel. The draft in the early passes was decreased and increased in the others, with the total reduction remaining the same. The results indicated a considerable improvement in the product from the ingot. This experiment confirmed the opinion, which had been prevalent for years, that the lightest drafts should be taken on the raw ingot surface and the heavier drafts reserved for the later passes. Drawing 35, Figure 1, shows the rolls, original drafts, and the revisions which reportedly increased the yield.

Most of the three-high blooming mills have now been changed to two-high reversing mills because of the greater flexibility of the two-high mill. The two-high mill is capable of rolling various size ingots as well as a variety of slab and bloom sizes. It also can roll longer lengths. Drawing 35 shows the rolls for a two-high blooming mill and the passes for the bloom used to produce 112 pound rails. Since this blooming mill rolls rails as its principal product, mostly from one or two ingot sizes, the passes are laid out so that the ingot is worked on the corners in all passes. This tends to prevent the corners from cracking which may occur more frequently when the ingot is rolled in a plain bullhead pass.

The square or rectangular bloom used in all rail mills must be formed quickly into the rail shape in order that the later passes may have proportionate reductions in all planes of the rail. If this is not done, the resultant unequal reductions in the later passes will set up stresses in the rail which may cause rupture. In general, the first forming operation is done in a series of two to four passes, in grooves which are sometimes called "hat" passes because of their shape, illustrated in Drawing 36, Figure 1. In this design the part of the bloom which forms the rail head is squeezed in, and the part which forms the base is spread out.

There are some variations in this design. Figure 2 shows a design where an edging pass is used to begin the shaping. The bloom is given two passes in this groove, similar to the manner of rolling in a reversing mill with screwdown, in order to return the bar to the front side of the mill for the other passes. Another design given in Figure 3 shows a method with two edging passes in the formation. In all three designs, the final passes are similar in shape.

The next step in the rail pass formation is to arrive



Drawing 39 — Sidework in hot passes. (above)

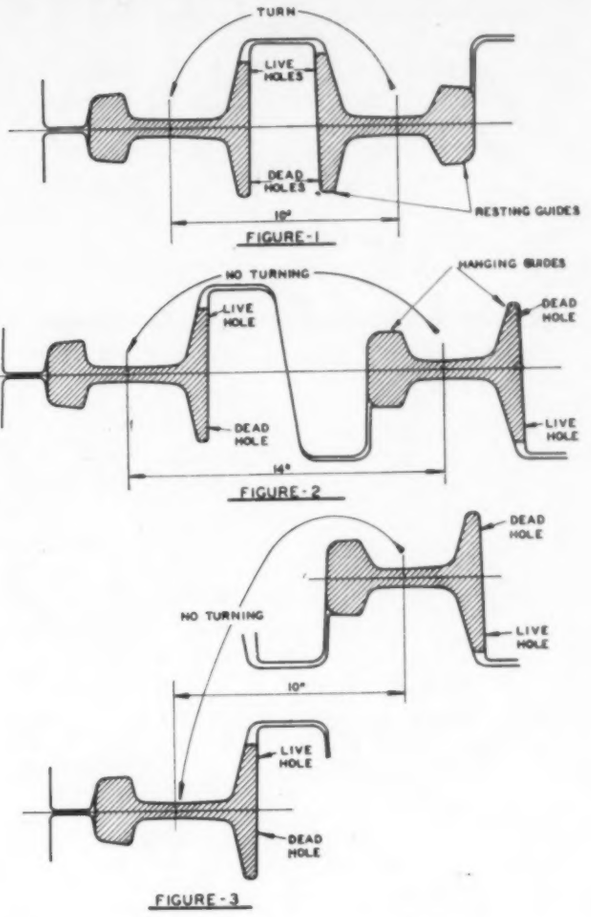
Drawing 40 — Some procedures of two-high mill compared with three-high mill. (right)

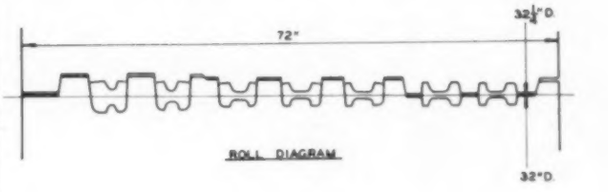
Drawing 41 — Passes for 95 lb English bullhead rail. (below right)

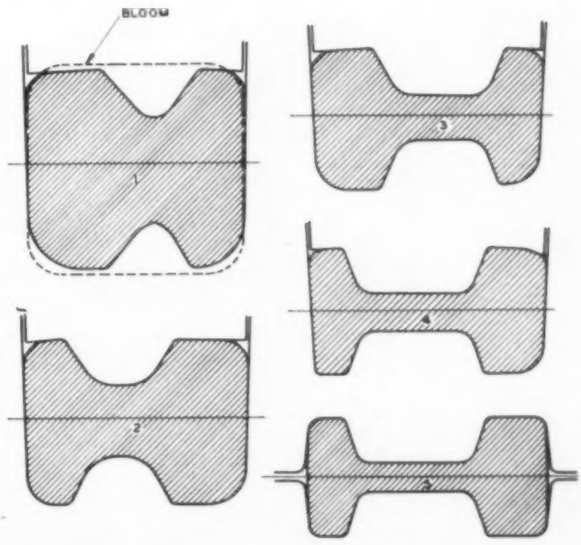
at the rough rail shape. Drawing 37, Figure 1, shows one of the oldest and most commonly used methods of doing this in two passes, which are called former and dummy passes. The former pass shapes the web and the dummy pass regulates the height and thins and spreads the flanges. The name dummy is derived from the fact that there is very little reduction in the pass, and what does occur is only in the flanges. Figure 2 shows a variation of the former pass. A collar on the head side of the pass prevents any spreading or finning of the head at that point. Figure 3 shows two diagonal passes taking the place of the former and dummy passes as used on some mills. Figure 4 shows a method where three diagonal passes form the web and are followed by a dummy pass.

Next, come the finishing passes illustrated in Drawing 38. In nearly all designs these are four in number. It is generally believed that four passes are the minimum that can be used to smooth out the roughness of the earlier passes and arrive at a true section with a relatively small amount of draft in the finishing and leader pass and thus assuring that large tonnages may be rolled before the passes are worn out. There are two designs used for the first three finishing passes, the straight design and the diagonal. In both of these designs the final finishing pass is the same. There are many divergent opinions as to the worth of the two designs.

The advocates of diagonal passes point out the fact that the passes do not become wide, consequently they can be dressed back to the templets when the rolls are worn and sent to the shop for dressing. Attention is also called to the greater amount of true rolling action obtained in diagonal passes. The advocates of the straight method point to the difficulty encountered from the end thrust on diagonal rolling and the wear that the bearing collars used in diagonal roll pass design receive.





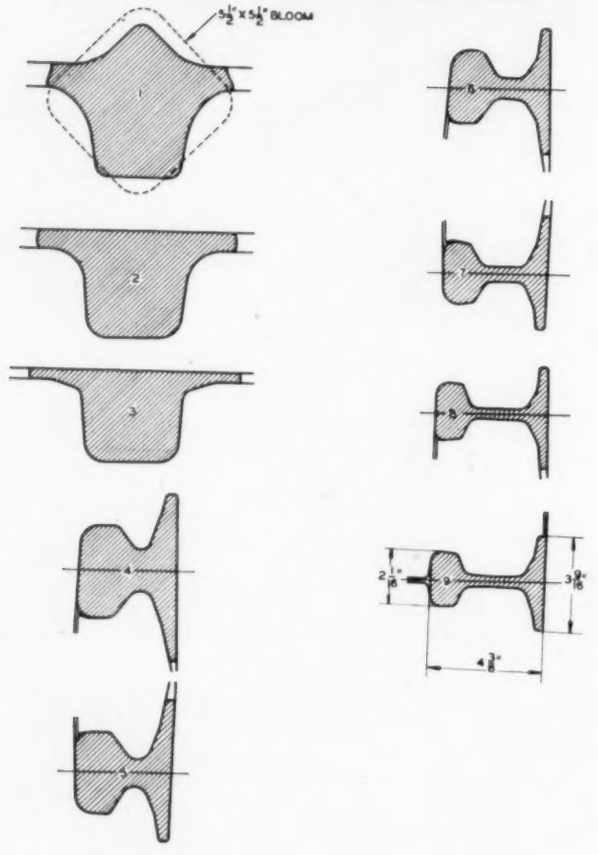


Impartial observers recognize that usable rails are made by either method and that the preferred design is more or less a matter of opinion.

The reductions in area in the finishing passes vary in different mills from about 5 to 15 per cent on 100 to 115 lb rails. Leader pass reduction varies from 10 to 18 per cent and gradually increases to the dummy pass where the amount of draft decreases. There have been cases where the draft in the dummy pass was as low as 1 per cent, in others, the draft has been as high as 8 per cent. Since the objective of this pass is to spread the base of the rail, there cannot be much reduction in area if the principal function of the pass is achieved.

In the former pass there is a heavy reduction in the web section of the rail. However, the total reduction in the rail shape is rarely more than 20 per cent, as considerable spread takes place in this form of pass.

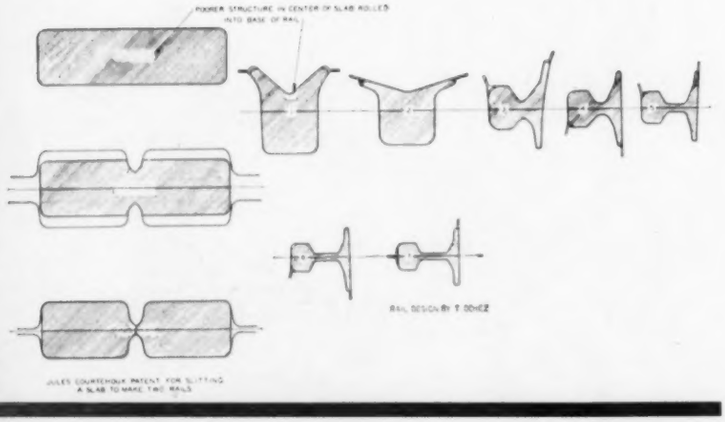
In the so-called hat passes, the percentages of reduction are not excessive, but the squeezing-in on these passes is considerable. It is not unusual to have more than an inch of squeeze-in per side in a pass of this type. Drawing 39 shows a total squeeze of 1⅝ in. The per cent of reduction in these passes will vary from a minimum of about 10 to a maximum of 30 per cent.



Drawing 42 — Old Holland rail design.

▲

Drawing 43 — Special German rail design.



TWO-HIGH VERSUS THREE-HIGH MILL RAIL PASS DESIGN

As previously stated, many English and some mills on the European Continent are two-high reversing as contrasted to the American three-high mills. One of the advantages claimed for the English two-high mill is that the roll expense is less and also that tilting and lifting tables are not required.

While it is true that in rolling rails the same number of passes may be used with two rolls as with three, the bar must be turned over from pass to pass in a two-high mill. Note Drawing 40, Figure 1. In order to get the same number of passes in the two-high as with the three-high mill, the passes must be designed as shown in Figure 1 and the rail must be turned over to alternate live and dead holes. To avoid turning the rail, the rolls would have to be arranged as in Figure 2, with staggered collars, whereby the turning is avoided but hanging guides are required for the passes where the dead groove is on the top. In this case the number of possible passes is less than in the scheme shown in Figure 1. It will be seen from Figure 3 that the same number of passes can be had in the three-high mill without turning of the bar.

Drawing 41 shows the passes and rolls for a 95 lb English bullhead rail as rolled at Middlesborough, England, on a 32 in. two-high reversing mill. These two-high reversing mills are typical of English rail rolling practice and are preferred over the three-high mills. You will note that after each pass the rail must be turned over in order to enter the next pass. The only exception is the last pass where it is not necessary to turn the rail in order to enter the finishing pass.

Drawing 42 illustrates a rather unique rail pass design. The passes are from an old Holland mill in which a 7 in. × 7 in. ingot was broken down to a 5½ in. square and entered into the first rail pass on the diagonal. After a pass or two the bar was turned and the rail finished in the usual manner.

Reference has been made to Dehez's design for rails. This unique rail design is known to have been in use in several plants and used by Jules Courtehoux for his patented method of rolling rails from a slit slab. Draw-

FIGURE - 1
EARLIEST FORMS OF STREET CAR RAILS

FIGURE - 2
FLANGED HEAD RAIL

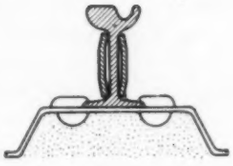


FIGURE - 3
EARLY TYPE GROOVED RAIL - 1879

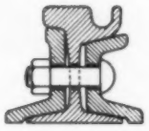


FIGURE - 4
IMPROVED TYPE OF GROOVED RAIL
1900

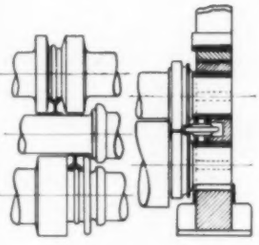


FIGURE - 5
ROLLS FOR GROOVED RAILS
PHONIX IRON WORKS - GERMANY
1879

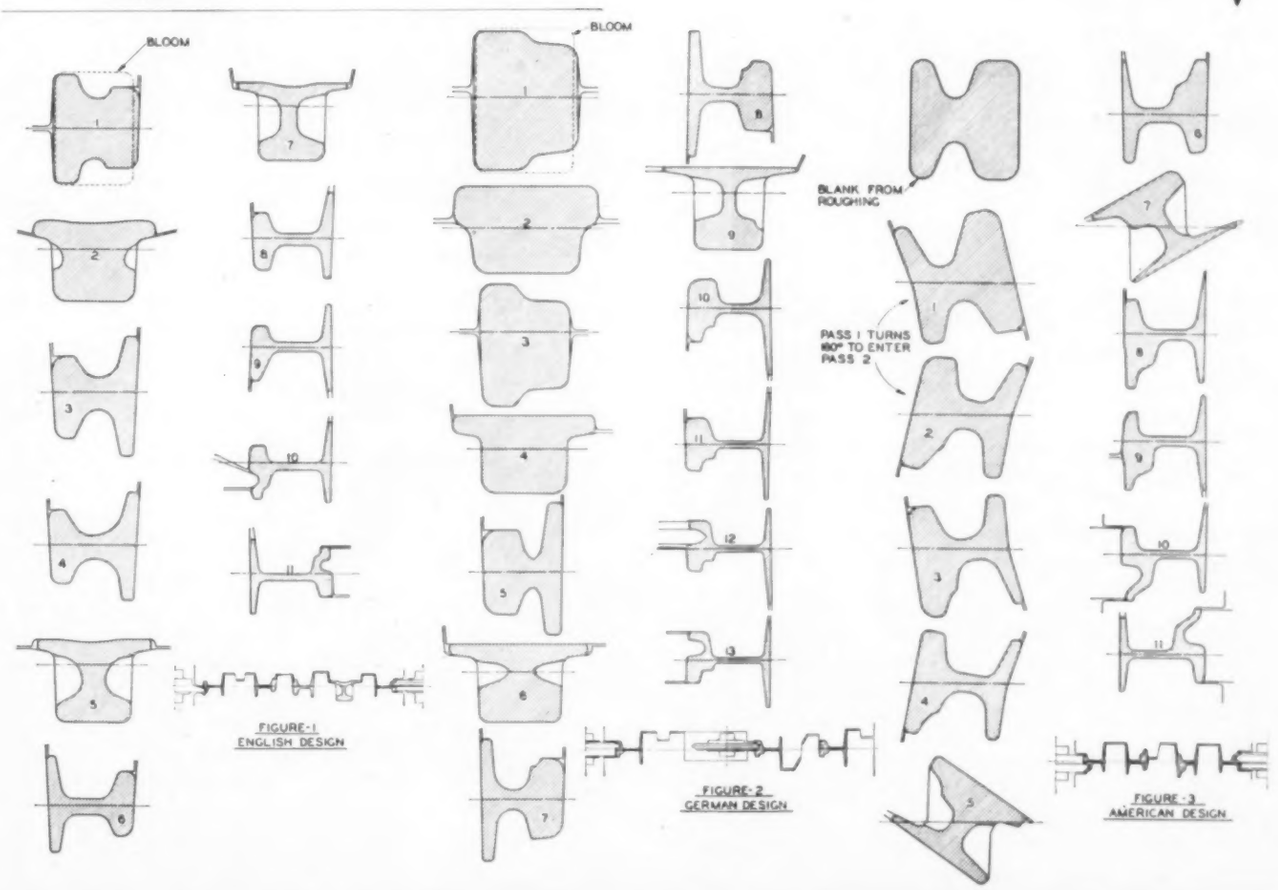
ing 43 illustrates the method. The passes and rolls shown are for a rail of approximately 90 lb. The passes are those used on a 37 in. two-high reversing mill. The drafting shown for the bloom entering pass 1 could only be accomplished by large diameter, slow moving rolls such as these. In some of the mills using this design, particularly the Hagendingen mill previously shown on Drawing 26, the passes are divided into three roll sets, the first having the two slitting passes, the second set having five passes and the third set two passes.

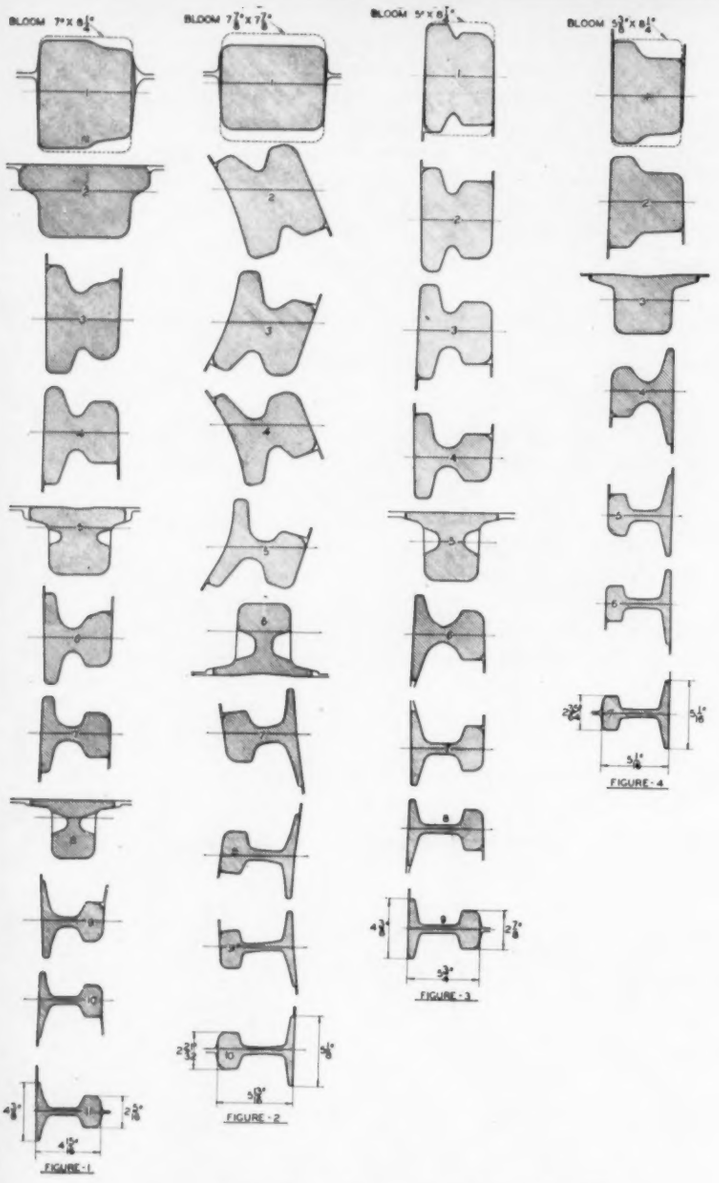
STREET CAR RAILS

Among the special types of rails rolled are the street car rails. These were first developed for horse drawn vehicles. With the development of the first electric street cars, shown at the Berlin Trades Exposition in 1879, considerable demand was developed for street car rails. Drawing 44 shows some of the forms of rails used. The first three in Figure 1 were laid on wood stringers. Figure 2 shows a flanged head rail laid between cobblestones. These tracks were hard to keep in repair and

← **Drawing 44 — Early street car rails.**

Drawing 45 — Several more modern street car rail designs. ↓





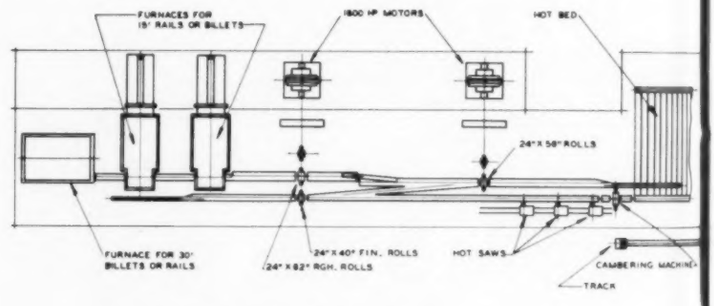
Drawing 46 — German rail pass design.

of the groove was accomplished by two rollers, which is the process used in most of the mills today.

Drawing 45 shows three designs used on three of the more modern mills. Figure 1 shows an English design of street car rail rolled in eleven passes on a 30 in. two-high reversing mill. Note that after pass 3 the rail is not turned over in entering pass 4. This means that any overfill out of pass 3 will not be rolled off in pass 4. Figure 2 of the same drawing illustrates a rail of German design, rolled in thirteen passes on a 33 in. two-high reversing mill. Drawing 45, Figure 3 shows an American design starting with a shape from a 32 in. mill, the shape being made in two passes from a rectangular bloom. The rail mill is a three-stand 28 in., two-high reversing mill. The feature of this design is that all the earlier passes are of the diagonal type. Note that dummy passes 5 and 7 are also diagonal.

FOREIGN DESIGNS OF TEE RAIL PASSES

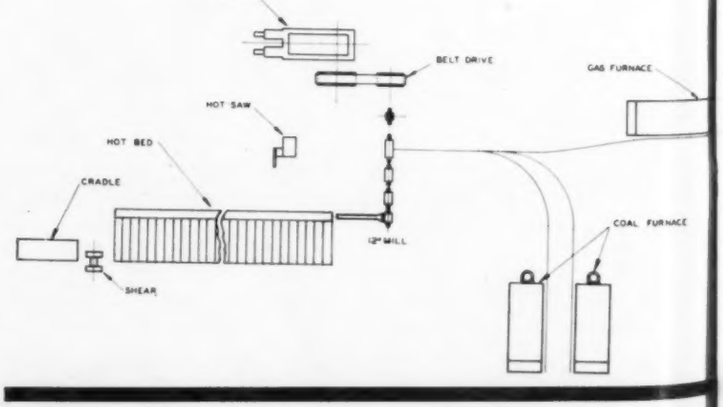
Drawing 46 shows a few German roll designs for tee rails. Figure 1 shows an eleven pass design. Figure 2 shows a diagonal design, completed in ten passes. Figure 3 shows a nine pass design in which the rail shape is started in the first pass. Figure 4 shows a seven pass design. It is quite common in Germany to roll rails in seven passes from the bloom, the blooms, however,



Drawing 47 — Light rail mill.

▲

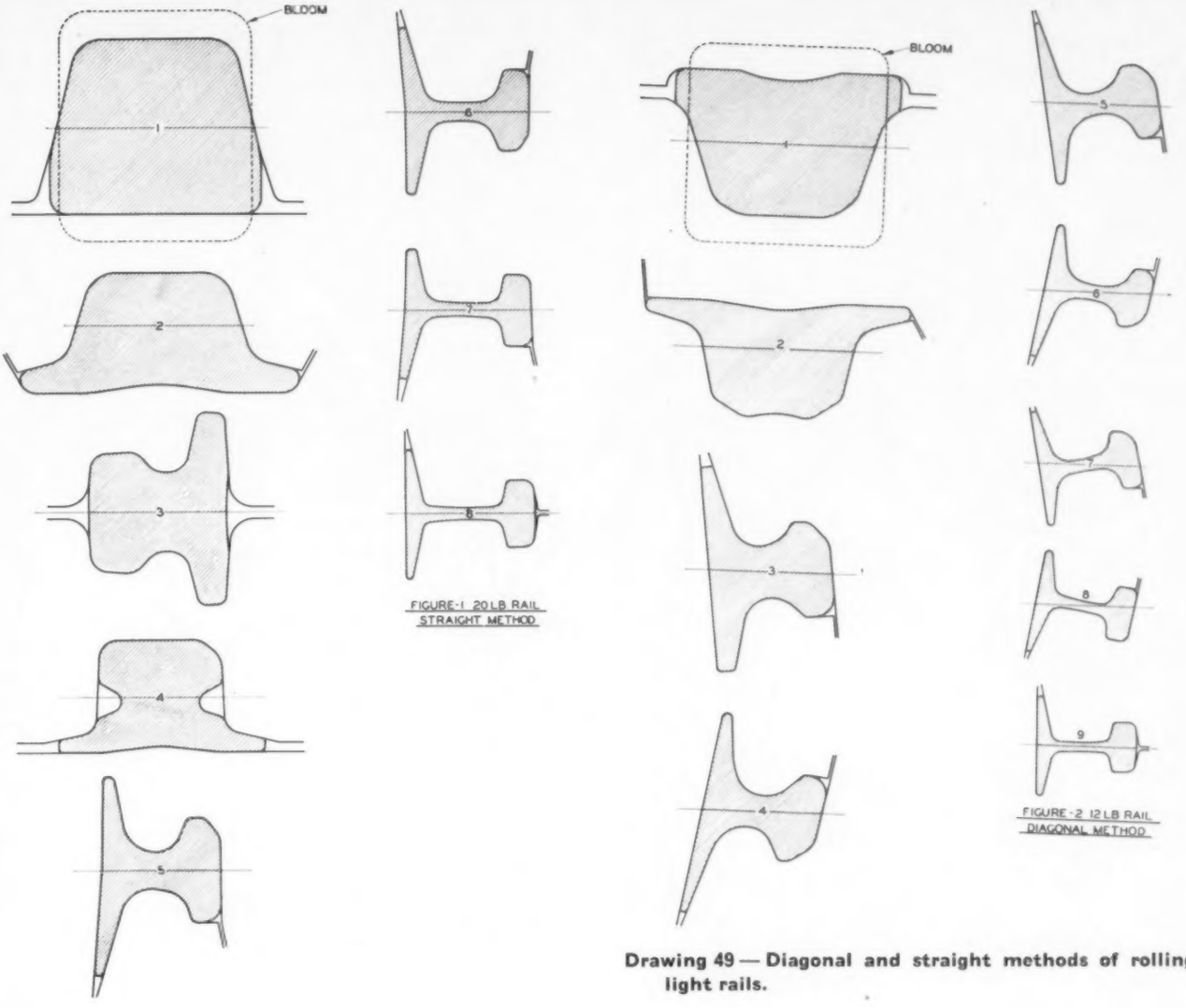
Drawing 48 — 12 in. hand bar mill.



this construction soon passed out of existence. Towns in England were among the first to use street railways, and the city of Plymouth was the first to request deliveries of street car rails of the grooved type. These rails shown in Figure 3 were rolled by the Phoenix Works in Germany.

G. A. Culins designed a grooved rail with which heavy fish plates were used. This was an improvement over any street car rail developed before his time, and are shown in Figure 4.

Figure 5 shows a process for rolling grooved rails which was first used in 1879 and patented in 1880. Three passes are used to roll the groove in the head, which consist of two open passes with the rail upright and one finished horizontally with the rail on its side in a closed pass with a vertical side roller. Later, rolling



Drawing 49 — Diagonal and straight methods of rolling light rails.

being usually less than 8 in. × 8 in. Even though there are less passes from bloom to rail on account of the small bloom size, the German passes usually show a smaller percentage of reduction per pass than is common in our mills. German roll designers consider this a better practice. The designs shown are for two-high reversing mills, a common type of mill used for rails in Europe.

LIGHT RAILS

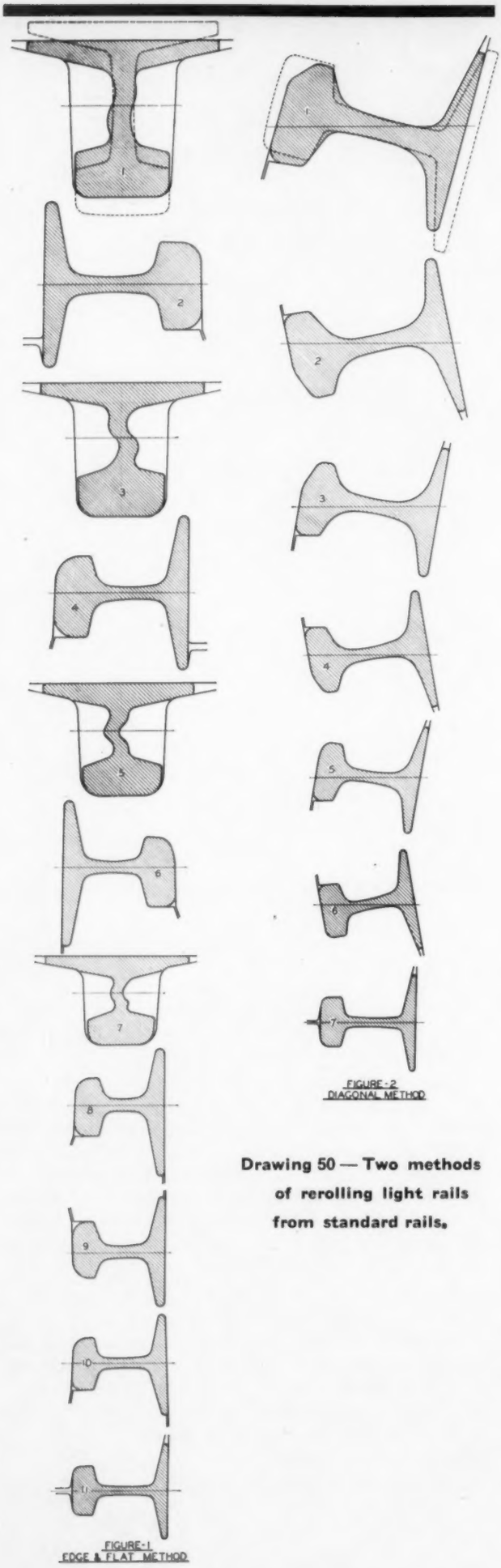
So far the mill and pass descriptions have been for standard rails. These may be from 50 lb to 152 lb per yard, although rails of less than 70 lb per yard are not considered today as standard rails. Light rails from 8 lb to 45 lb per yard are rolled on a variety of mills, mostly bar mills, although a few mills have been built and operated exclusively for light rails.

Drawing 47 illustrates a mill which was designed and built to reduce heavy standard rails to light mine rails by the diagonal method of rolling. The mill was equipped with a roller straightener for straightening the rails, but this practice was later abandoned and the rails are now straightened in gag presses.

Drawing 48 illustrates a 12 in. hand bar mill which rolled, as a part of its varied product, rails from 12 lb to 45 lb per yard from large rails or from billets. The rail reducing was accomplished by a flat and edge reducing method in the roughing passes. The mill had two hand fired coal reheating furnaces and one gas furnace. This mill was once considered to be one of the best tonnage producers of the hand bar mill type in the country.

The rolling of the larger sizes of light rail from billets is accomplished in much the same manner as the rolling of standard rail with hat passes, former, dummy, and finishing passes. An average of nine passes is generally used. The smaller sizes of light rails have been rolled on hand bar mills equipped with rolls as small as 8 in. in diameter with as few as six passes, and with five passes in extreme cases.

Drawing 49 illustrates a variety of passes for light



Drawing 50 — Two methods of rerolling light rails from standard rails.

rails as rolled from a billet on the light rail and bar mills.

In the rerolling of light rails from standard rails there are two pass systems illustrated in Drawing 50 for 12 lb rail that have been in general use. The oldest one is the edge and flat design. In this design the standard rail is brought from the heating furnace and put in a roll pass with the head down and flange up in the rolls, and then squeezed down in this pass, in which there is practically no reduction in area. The rail is then turned on its side and given a normal reduction, then turned up right and alternately edged and flatted in the roughing passes to a size suitable for the finishing stand, where it is worked in the usual way. It will be noted that by this method the actual rolling takes place only in the horizontal passes.

A newer and much better design has been developed wherein all the passes are diagonal, and rolling and edging-down in height are accomplished in each pass. The reduction in height and the actual rolling in this design are done in the same pass, and thus fewer passes are required than in the design shown in Figure 1.

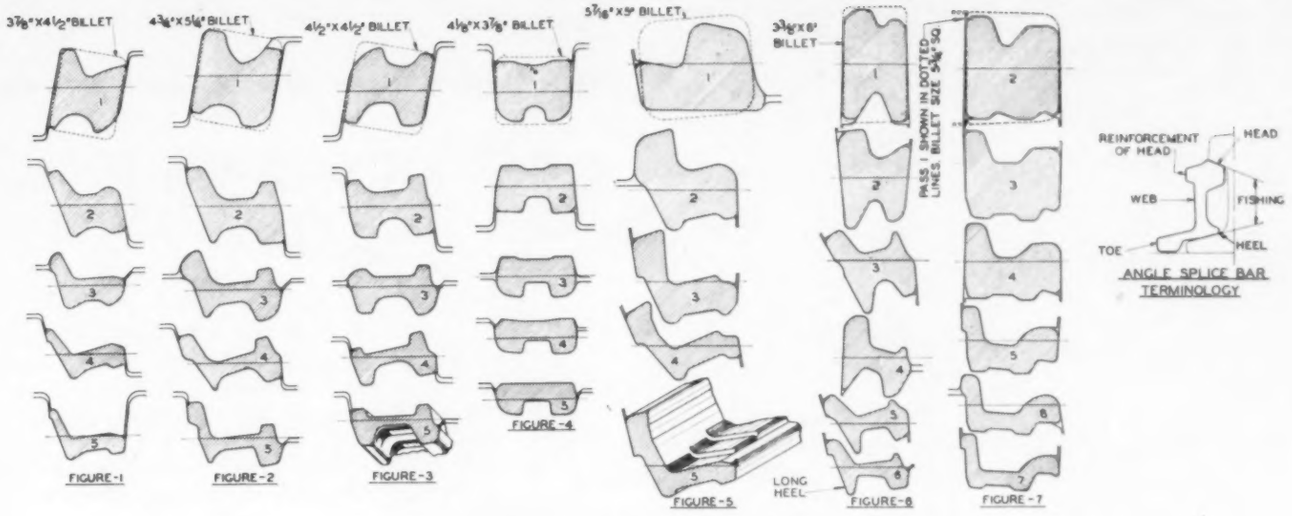
Some years ago a process was developed for rail reducing or perhaps it would be better to say rail reconditioning, which was known as the McKenna process. In this process worn rails were reconditioned by grinding and rerolling the rail to a slightly smaller size.

ANGLE SPLICE BARS

Many rail mills roll angle splice bars as well as rails and this discussion would hardly be complete without some description of these sections.

The design and use of angle splice bars have involved considerable experimentation. Until recent years no attempts have been made to standardize, and as a result many types of joints are in use. In fact, there are several designs of joint bar for rails of the same weight. As an example, in one steel plant there were twenty different splice bar designs rolled for one size of rail.

Among the many kinds of angle splice bars in use today, there are four distinct types of special interest which are shown in Drawing 51. Figure 1 is a long toe standard bar used for the A. S. C. E. type rail. Figure 2 illustrates another long toe bar with reinforcement at the back of the head. Figure 3 is a design for a patented reinforced bar. Note the corrugations rolled in the finishing pass on the bottom of the web and also note the short toe and reinforced head. Figure 4 illustrates a special type bar without toe and with no reinforcement in back of the head. These first four figures cover the general types of angle splice bars in use at the present time. Figure 5 shows an unusual type bar with reinforcement in the web of the bar, once popular on a Western railroad. The reinforcement is rolled-in in the finishing pass. Figure 6 shows a bar with an unusually long heel. This long heel presented a problem in roll pass design. The designs used for Figures 1 to 5 would



Drawing 51 — Angle splice bar pass design.

not be suitable for this section so it was decided to use beam roll castings available for the first two grooves, and provide a design which would insure sufficient stock for the heel right at the beginning. As a further safeguard pass 4 was turned as shown using a live pass for the heel to insure enough stock at this point. Figure 7 is a foreign design credited to Dehez. This unusual shape of joint was rolled in the early 1900's, on a three-high 24 in. mill from a 5¾ in. square billet.

CONTINUOUS RAIL JOINTS

Among the rail connections very popular at one time and still in use are the sections known as continuous rail joints, illustrated in Drawing 52. These sections are rolled with the lower base flared, the flare being pressed in to a size which fits the rail base as the bar is punched.

Figure 1 shows the six passes used for a continuous joint to fit a 90 lb rail. Figure 2 shows the eight passes for a joint for a 100 lb rail. The passes for these two sections are interesting examples of the effect of direct and indirect rolling action; that is, direct rolling where drafting is done on the bar at the point where it is practically parallel to the axis of the roll as contrasted with work done by somewhat indirect rolling where the drafting is done with the pass set in the rolls at an angle with the roll axis.

Pass 2 of the 90 lb section shows the toe of the bar, as indicated by the figure, almost parallel with the roll axis, thereby giving a direct rolling action on this part of the bar. A well known principle, used effectively in roll designing, is the fact that an entering section, dotted lines, going into a pass, heavy lines, will spread considerably in the toe or thin part of the bar as shown in the figure. This is because there is very little reduction in area on the other parts of the bar, consequently, little or no elongation on these parts. As the heavy side does not get appreciably longer, the metal being rolled must go somewhere and so spreads into the toe.

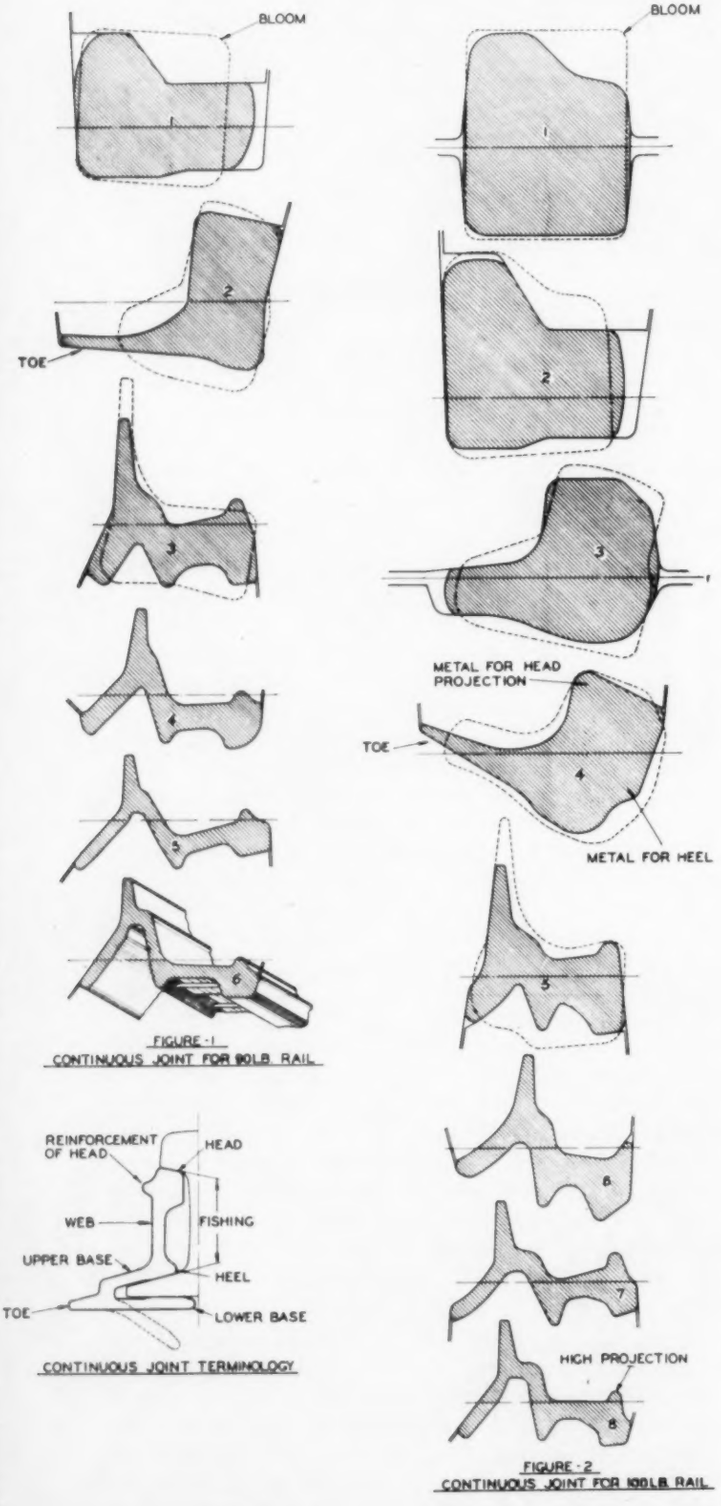
The section shown for the 100 lb rail is one where the projection on the head of the bar is high, as indicated on the drawing, and in order to fill this part of the bar properly it was found necessary to have the correct amount of material in pass 4. The resulting shape of this pass is such that it required tilting to a point where the toe portion of the pass is at a considerable angle with the axis of the roll, thus making for more indirect rolling action on the toe than is obtained in the 90 lb section. At the same time, in order to fill the heavy side at the point where the metal is added for the head of the section, it was necessary to have sufficient draft on this side of the bar to fill the pass, and the resulting shape of the pass necessitates it being set at this angle. As a result, a heavy reduction on the toe side would cause a choking action upon entry on account of the indirect rolling action on the toe. At the same time the reduction on the heavy side would cause considerable elongation on that side and the smaller toe part of the bar would be drawn along. Consequently the metal would not spread out and fill the toe side of the bar. For these reasons it was necessary to use eight passes on this section, as compared to six passes for the 90 lb section. This was done to spread and thin the toe part of the bar before it entered pass 4 so that it was thin enough not to be choked, and long enough to fill the toe part of pass 4.

This example from actual practice illustrates the principles of spread and elongation which play such an important part in the design of every shaped section. Actually this 100 lb section was first designed to be rolled in six passes. It was not successful because the toe part of the bar had an underfill of ¼ in. in its height. It was recognized at the time of the first rolling that the toe could not be filled and the other passes

were subsequently added. The next rolling was successful.

Search of the literature on rolling technique for purposes of this paper has been the source of many surprises. Many of the mills and rolling processes, believed to be of modern design, had been designed and in many cases actually tried years before. The old saying, "There is nothing new under the sun," again seems apropos.

Drawing 52 — Continuous rail joint pass design



DISCUSSION

PRESENTED BY

C. W. BARRETT, Roll Designer, Republic Steel Corporation, South Chicago, Illinois

R. E. BEYNON, Superintendent, Roll Shop Division, Carnegie-Illinois Steel Corporation, South Chicago, Illinois

J. J. HEIN, Assistant Superintendent, Roll Department, Inland Steel Company, East Chicago, Indiana

C. W. Barrett: Mr. Beynon talked about the sharp inclined surface on the sides of the leader pass; is a lubricant used on that?

R. E. Beynon: We are not rolling rails any more, but when we did, we used a lubricant there.

C. W. Barrett: I'm rather curious as to the action you got from the lubricant. I have used a very light oil with more or less of a 10 SAE rating, and also a vegetable oil, a soluble oil which does not have a tendency to burn, but I have not had the same results with the vegetable oil as with the motor oil.

R. E. Beynon: I can't answer your question because my experience has all been with suet. I have never observed the use of the other so I can't answer your question.

J. J. Hein: I would like to ask Mr. Beynon how many rail mills we have in the North American continent that roll rails direct from the ingot and how many mills do we have that roll rails from reheated blooms?

R. E. Beynon: There are eleven active heavy rail mills in the North American continent and to the best of my knowledge, there are three of them that roll direct from the ingot and the others reheat the bloom.

Member: You said you used suet. What is the difference there?

R. E. Beynon: In our case, we have rolled as high as 5000 tons in one finishing pass by using suet and that is considered a very good tonnage. Two thousand tons is considered fairly good.

Member: Have you ever thought of using graphite as a lubricant?

R. E. Beynon: There is considerable agitation along that line right now. So far, I don't believe it has been very successful.

Friction Sawing - PAST AND PRESENT

. . . . friction sawing of cold steel is being used in an increasing number of applications . . . . this paper describes the principles of the process as well as some of its applications . . . .

by James M. Lewis, CONSULTING ENGINEER

KLING BROTHERS ENGINEERING WORKS

CHICAGO, ILLINOIS

▲ FRICTION sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Friction sawing of steel permits faster cutting than with any other known process except shearing. Yet because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Many engineers, designers and users of machines have been trained to consider friction as a destructive force which is to be avoided wherever possible, with the result that they have become "anti-friction" minded. This condition may partially account for the present lack of reference data on the subject of friction sawing in our text-books and engineering handbooks.

However, there are on record some articles about the use of friction sawing dating back as far as 1823, and this article is intended as a review of the past published record as well as an additional record of later applications of friction sawing, together with a further explanation of the process.

The friction saw is in a sense the direct opposite of the ordinary cutting tool or slow speed saw. Consider a high carbon steel lathe tool cutting against the rim of a slowly rotating steel disc. If the rim velocity of the disc is increased, a surface speed is reached where the tool will burn. By increasing the speed of the disc further, the tool will stop cutting the disc and the disc will start removing metal from the tool. Increasing the speed of the disc still further allows it to cut easily through the tool by a friction action with little wear on the disc.

The cutting action has been reversed by an increase in speed of the disc beyond the critical speed at which the tool stops cutting the disc. Obviously the cutting capacity of the lathe tool is limited by the critical speed, while the cutting capacity of the disc is limited to that speed zone between the critical speed and the speed at which the disc would burst. The safe operating speed zone above the critical speed is so much greater than the zone below that a much faster rate of removing steel is possible with friction sawing than with any sawing method requiring an operating speed below the critical speed.

The removal of steel by friction sawing is highly spectacular. It emerges from contact tangentially with the blade in the form of a steady stream of brightly

Presented before the Pittsburgh Session of the AISE Annual Meeting, Sept. 26, 1945.

sparkling particles, similar to the action of grinding but of greater intensity. Additional sparks continue to leave the rim of the disc after the point of emergence but in diminishing volume around to the point of contact.

The cooling effect of air on the exposed part of the rim is very high because of the high rim velocity and resultant fan action, and is directly responsible for dissipating sufficient heat from the blade rim to prevent the rim from reaching the temperature which is present on the piece being severed.

However the cooling effect of air alone is not enough to prevent some temperature rise on the blade periphery. If the ratio of the arc of contact to the arc of cooling is sufficiently high, and the duration of cut long enough, the entire exposed periphery will eventually display a visible red heat rapidly distinguishable from the sparks leaving the rim. This red heat will extend deeper into the rim with further duration of the cut, but will disappear very quickly upon the instant of completion of the cut.

At that high a temperature, the original even rim surface will deform by rounding of the corners and widening into a shape similar to that of a mushroom. At these temperatures, metal being removed will adhere to the rim of the saw. This accounts for the fact that the rim of a soft steel blade may become very hard if cutting material which will receive a hardness if heated and quenched very suddenly. At the same time, the rim will remain soft if cutting low carbon steel without sufficient alloy content to allow hardening of the metal which may adhere to the rim.

There is apparently no loss of metal from the blade rim even if deformed to as much as double the original width or more. A deformed blade will continue to remove metal but will require more energy because of the increased heat generating surface area of the rim, and the correspondingly increased surface area of contact of the section being severed.

The rounded corners of a deformed blade rim produce considerably more burr on the edges of the sawed faces as the blade rim emerges from contact, than is produced if the corners of the blade rim are sharp.

Obviously rim deformation and adherence of foreign metal are dependent upon whether the rim becomes red hot before completion of any cut.

If heat is dissipated from the blade rim with application of a coolant in a manner so the rim cannot reach a red heat or show any indication of red heat on the periphery immediately ahead of contact with the material for the entire duration of every cut, there will be no adherence of foreign metal to the rim regardless of the type of steel being severed. Furthermore, the deformation of the rim is reduced to such an extremely low value that successive cuts, to the extent of several hundred, can be made without showing any appreciable change in the energy required, or showing a resultant burr on the severed material.

The importance of proper cooling is so great that it marks the passage of an age when excessive rim heat was accepted as normal or unavoidable.

The difference in blade performance with proper and improper cooling is so striking that it truly marks the difference between friction sawing of the past and present.

Friction sawing is not a cure all method of cutting any and all metals but is apparently limited to the cutting of steel. Friction sawing is not a new or revolutionary process but rather one that has been applied very successfully in its field by an ever increasing number of users.

Friction sawing may be described as a method of severing any steel section with a steel blade, having a much larger peripheral surface than the maximum length of contact engaged with the section being cut, and operating at sufficiently high uniform velocity, and under sufficient pressure to generate heat by friction on the contact surface of the section at a rate which is faster than that surface can absorb heat. The resultant temperature rises of the two surfaces are unequal and are greater on the material having the smaller contact surface. When the contact surface of the piece being cut reaches a temperature at which it is red hot, its tensile strength reduces very rapidly and continues to reduce as the surface gets hotter. Meanwhile the blade periphery is relatively colder and consequently it is relatively much stronger than the weakened contact surface. At some point, above red heat but below the melting point, the weakened surface can no longer resist the sliding action of the blade periphery and it is wiped away. The removal of the initial surface exposes succeeding surfaces immediately below to the same action and the process continues until the section is severed, provided that the blade and driving mechanism have sufficient capacity to continue the generation of heat at a rate which is faster than it can be absorbed by the maximum length of surface contact of the material.

The blade should be capable of withstanding the entire severing period so that each portion of its periphery will continue to emerge from the surface of contact at a temperature below that at which it will fuse to the hotter material emerging from the blade.

Friction sawing of steel is a true sawing action, as proved by the fact that chips are removed in the form of flakes of true metal in its unmelted condition, which chips oxidize and cool very rapidly upon contact with air because of their small size. Examination of the cold flake shows an impression of the blade on one side while the other side is rough. This indicates that the contact surface was reduced in strength by heat until it could not further resist the sliding action of the blade and was pulled away from contact with the colder metal beneath and at the sides of the surface so removed. Examination of the sawed surfaces of the steel section shows them to be rough in appearance similar to the underside of the chips. The surfaces also show that they were subjected to localized heating at a temperature well below the melting temperature, but a temperature which permitted sufficient reduction of strength for the contact surface to be pulled away.

The sawing of any material is generally described as the removal successively of minute portions of the material by the cutting or tearing action of a series of sharp edges thrust against the material.

Friction sawing of steel may therefore be described as a sawing method because it removes successively minute portions of steel by reducing the tensile strength of the contact surface to a point which permits its being pulled or torn away by frictional contact with the blade. The blade may be either with or without sharp edges,

as long as it is operating at any speed above the critical speed.

The temperature required on the contact surface of steel to ensure that removal takes place by friction sawing is necessarily at, or higher than, a red heat but considerably lower than the various melting temperatures of all steels, and is probably between 1600 and 1800 F.

The energy required to sever any given steel section varies inversely with the initial temperature of the steel, being greatest if the steel is cold to the hand, and reducing to about $^1/_6$ if the steel is at 1400 F.

In order for the process to take place, the blade must generate heat on the contact surface at a rate which is faster than each succeeding contact surface area can absorb heat.

For a given width of blade periphery, operating at sufficiently high uniform velocity, the limiting length of surface contact, at which removal of metal ceases, varies directly with the pressure of the blade against the surface, and increases as the pressure increases.

The power required to maintain uniform velocity increases directly with the pressure. Hence the blade, and driving mechanism must have sufficient capacity to maintain uniform velocity while sufficient pressure is being exerted to generate more heat than can be absorbed by the maximum length of surface contact to be encountered.

A blade having a smooth rim will permit continuous production cutting of all high carbon steels in their hardened or annealed condition, where the carbon content varies from 0.60 to 1.00 per cent. On such materials the rim becomes roughened in a very few cuts, and with proper cooling will continue to sever such steels without welding of material, and without other noticeable deformation, until, after many cuts, the outside corners of the rim will lose their original sharpness and will begin to show a slight rounding. Such rounding will cause a slight increase in the amount of burr produced on the severed faces of the steel along the edge where the blade emerges. The energy required for succeeding cuts of the same section area and shape will remain very nearly the same. Redressing is necessary to bring back the sharp corners of the rim, and is generally done at the end of a working shift of eight or ten hours by means of machining or grinding the blade when turning it, at slow speed either on a saw arbor or removed to a separate machine. The amount of metal to be removed from the rim during redressing is only that depth to which the corners have rounded, and this is generally not more than $\frac{1}{32}$ inch and seldom as high as $\frac{1}{16}$ inch. On steels having lower values of carbon content, the smooth rim blade will not roughen but tends to glaze into a smoother surface.

By indenting the rim in a manner resembling gear teeth of about $\frac{1}{4}$ inch pitch, the blade will readily sever any of the lower carbon steels with less energy than that required by the smooth rim blade when cutting high carbon steels of the same section area and shape. On low carbon steel, the tops of the teeth do not roughen with continued cutting. With proper cooling, the rim will not adhere to foreign metal, and the resultant small burr on the material, and energy required, will remain nearly constant through several hours of cutting.

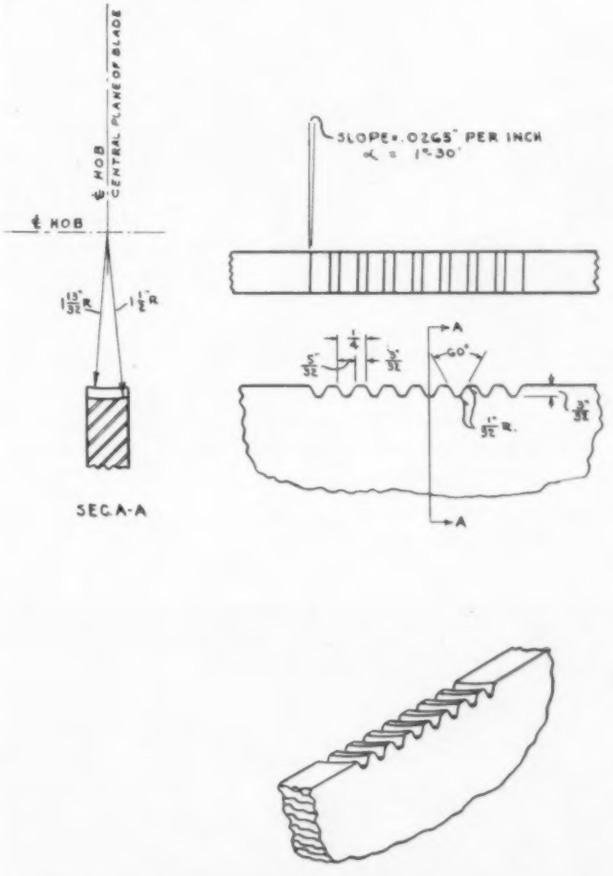
Here again the eventual rounding of the outside corners, formed by the tops of the teeth and the sides of the blade, determines the point at which the blade should be redressed.

After eight to ten hours of continuous production cutting of various low or medium carbon sections within the capacity of the blade, the resultant burr and energy required may have increased sufficiently to warrant redressing of the blade.

The blade may be redressed by the same hobbing operation that is used for forming teeth in the original blade. The teeth produced by the Kling friction saw blade dressing machine are as shown in Figure 1. A topping and serrating hob having a three inch outside diameter and single thread with $\frac{1}{4}$ inch circular pitch produces the necessary indentations and also cuts off the tops of the teeth concentric with the center bore in the same operation, at the rate of 15 inches of rim surface per minute.

The 30 degree negative angle of the front and back faces, together with the $\frac{1}{32}$ inch radii at the upper and lower corners of the teeth, provide a tooth shape which is very strong and has a minimum tendency to adhere to the metal being removed in operation. The $\frac{5}{32}$ inch space between teeth provides the desired indentation which is necessary to permit effective removal of the heated surfaces of low carbon steels. The $\frac{3}{32}$ inch top surface provides a total rim heating surface of 37½ per cent of that of a smooth blade, and this ratio of

Figure 1 — Sketch shows tooth form for one type of friction saw blade.



tooth surface and spacing has been found to be very effective for the friction sawing of cold steels having low or medium carbon content, where the length of the blade contact varies from line contact to several inches of contact. It can be used for the cutting of high carbon steels with a degree of success which is apparently comparable to that of the smooth rim. Apparently all of the alloy steels in either their hardened or annealed cold condition are also able to be cut with little change of energy or resultant burr.

There are other methods of indenting the blade periphery, such as nicking with a cold chisel driven radially into the rim at intervals of about ¼ inch, with hand or power tools. Such methods cause the rim to be widened and permit using a flat disc without hollow grinding for side clearance. However such methods develop stresses which may be objectional, produce a wider kerf than may be necessary with correspondingly higher energy requirement, cause rough surfaces on the sawed faces of the severed material, and require the use of a steel which is of low enough carbon content to permit sufficient ductility to allow indenting the rim readily.

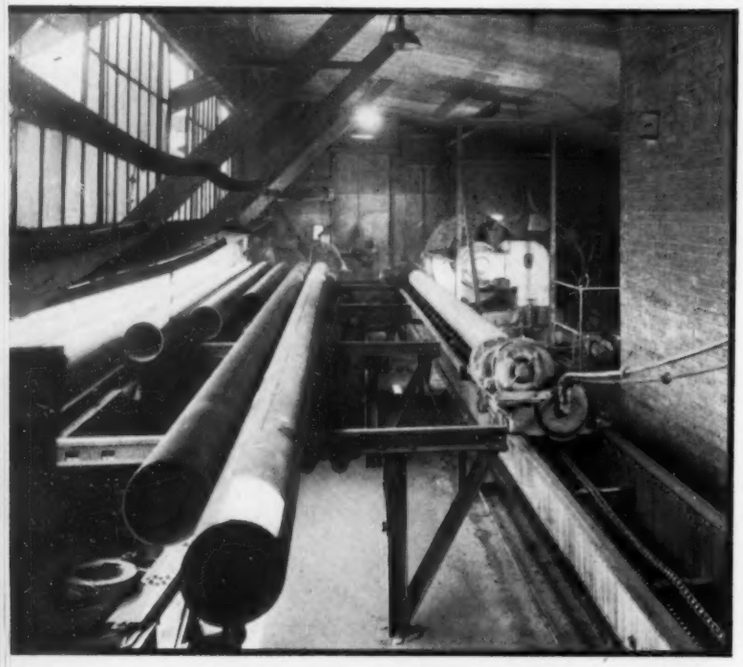


Figure 2 — The 58 in. saw shown is used to cut pipe stock into short lengths for bomb casings.

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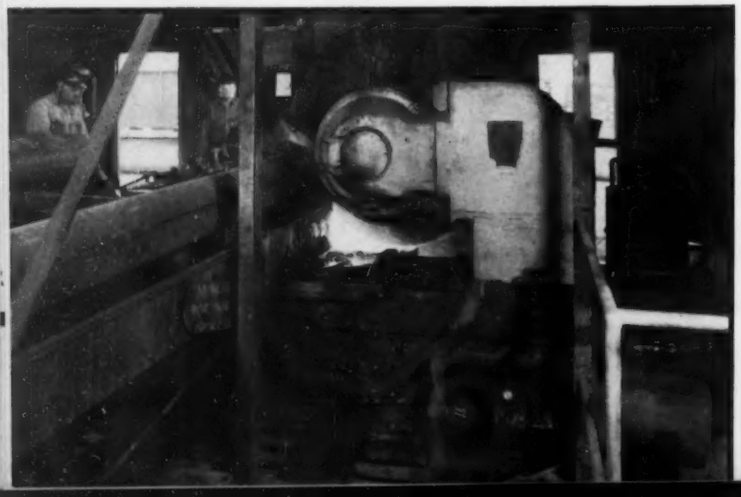
Figure 3 — The blade is here cutting a 10¾ in. outside diameter pipe in 10 seconds.



The hobbing process requires hollow grinding of sufficient amount on the sides of the blade, from the rim to the collar diameter, to provide side clearance, so that the rim alone will be in contact with the material, and permits the use of a steel of higher carbon content and tensile strength. However the carbon content for either the smooth or hobbed blades should not exceed 0.45 per cent, and other alloys which would allow excessive hardness to develop are to be avoided. For in operation, the rim is continuously being heated and quenched through each revolution for the entire duration of each cut, and the temperature of the rim upon emergence from contact may be high enough to allow a hardening action to result. With proper dissipation of heat during each revolution, this grade of steel will develop further refinement of the grain structure on the rim surface without excessive hardness, as evidenced by the fact that it can continue to be redressed by a hobbing or lathe tool process. There is also the possibility that proper cooling may be neglected and, if this should occur, the blade rim will continue to rise higher in temperature with each succeeding revolution until it reaches the point at which adhesion of foreign metal occurs. The above recommended grade of steel will stand this abuse and will still be machinable unless the adhered metal is of high carbon or high alloy content, in which case the rim surface may be too hard to machine and may require removal by grinding.

This steel has been used in the manufacture of many thousands of friction saw blades requiring peripheries which are smooth or indented. These have given excellent operation without occurrence of hardness cracks in cutting various sizes and types of cold steels where the contact surface has been several inches in length.

The efficiency of friction sawing increases with the rim velocity for speeds up to about 20,000 feet per minute but seems to remain nearly constant for higher values. The machines are built to provide substantial mounting of the blades to permit rotation in a true plane at uniform rim velocity of not less than 20,000 feet per minute for a minimum size blade and not more than about 28,000 feet per minute for the maximum size of blade.

At such high rim speeds, the centrifugal force is sufficient to cause a flat steel disc to stretch more at the rim than at points closer to its center. This causes the blade to tend to increase in circumference more than in diameter, with the result that the rim will flutter sidewise. To prevent this, the blade must have sufficient tension developed in the rim so that it will rotate in a true plane, when brought up to full speed, without showing any tendency to flutter sidewise. Rim tension is developed by hammering both sides of the blade from the center out to within a few inches of the rim.

The steel used for these friction saw blades permits the development of sufficient tension to allow long service and several redressings, usually until the blade is too small for further use on the machine.

There are two other types of circular blades which rely upon the heat of friction to allow a severing action to take place on steel, namely tube saws and hot saws, both of which permit a substantial reduction in the per cent of tooth surface.

Tube saws are made of higher carbon steel with alloying elements which provide a greater hardness, thus requiring sharpening by grinding in the development of teeth. These have a sharp cutting edge similar to those of a slow speed saw, with a very slight positive front rake and varying angle of top rake, and length of land. They generally have a close pitch of ¼ to 5/16 inch, and are intended to run in a forward direction. In operatioh they are limited generally to the cutting of small sections where the maximum length of contact will not exceed more than about ¾ inch, as the sharp edges will dull very quickly when this length of contact is exceeded. When dull they operate entirely by the heat of friction for which the steel is unsatisfactory because of an analysis which permits hardness cracks to occur. Oddly enough, these blades seem to operate as well, if not better, when run backwards, which indicate that the action is basically friction sawing.

Hot saws are in reality friction saws which are used for severing steels, when at a red heat or higher, by generating additional heat with friction on the contact surface, at a rate which is faster than that surface can absorb heat. The resultant increase in temperature on that surface causes sufficient further reduction of tensile strength to allow it to be removed by the colder blade.

The hot saw blade has an indented periphery with teeth having a 30 degree negative front and rear angle similar to those used to advantage for friction sawing. But they have a larger spacing of ¾ inch or more and the top surface of the teeth is about 1/16 inch long which provides a heating surface for the teeth about 8 per cent of the total rim surface.

Such a blade will cut steel at 1400 F with approximately 1/6 the energy required when the same steel is cold, as stated previously. Proper cooling to prevent heat accumulation in the blade rim prevents adherence of foreign metal and allows long blade life before the outside corners of the teeth round sufficiently to require redressing. They are operated at rim speeds generally not over 18,000 feet per minute.

While tube sawing and hot sawing are definitely related to friction sawing, the primary purpose of this article is to outline the progress made in the field of severing cold steel sections where the length of contact is appreciably more than that which can be successfully severed by blades other than circular friction saw blades.

For friction saw blades, cutting cold steel sections, with uniform rim velocity of about 24,000 feet per minute, the minimum rim thickness is 5/32 in. for a 24 in. diameter saw and increases at the rate of 1/16 in. with each additional foot of diameter for proper tension.

The power which the 24 in. blade will withstand is limited to that of a 25 hp driving motor, and as the diameter and thickness are increased, the power may be increased by at least 25 hp per additional foot of diameter.

With complete heat dissipation during the arc of cooling, the safe length of contact which allows the rim to emerge from contact without excessive heating is about 3 in. for the 24 in. blade, and seems to increase at the rate of 2 in. for each additional foot of diameter.

The rapid cutting time for various cold steel sections which can be obtained with these blades are shown in Tables I and II.

The cutting times shown in Tables I and II are for hollow-ground, hobbed blades in average condition, driven directly or indirectly, with high mechanical efficiency, by constant speed motors, operating at the values of load shown. These times will be less when the blades are newly dressed, and greater when the blades have developed sufficient deformation to require redressing. It is necessary to assume that the machine provides:

1. Mounting of the blade to allow rotation in a true plane.
2. Motion of the blade stroke in a plane parallel with the plane of rotation.
3. Uniform blade rim velocity for the entire duration of each cut.
4. Heat dissipation from the blade rim for the entire duration of each cut.

Table I is for machines providing adjustable blade pressure on the contact surface, central with the direction of the blade stroke, either horizontally, or vertically downward. This permits:

1. Constant blade pressure.
2. Uniform motor load of desired value.
3. Uniform rim velocity for the entire duration of each cut.
4. Continuous production cutting of stationary, solid or hollow, steel sections of large area, where the maximum length of contact approaches the safe limit for the blade, and this length cannot be reduced except by rotation of the material.
5. Use of a standard, constant speed motor, having normal-torque, low-starting current, and lower pull-out torque characteristics, which may be started with full voltage.

TABLE I

Cutting data for machines providing direction of blade pressure in line with direction of blade stroke.

Blade diameter, inches	24	36	48
Blade rim thickness, inches	5/32	7/32	9/32
Blade, rpm	3500	2375	1750
Motor load, hp	25	50	75
Average cutting time in seconds for size of cold steel section below:			
1 in. solid round	2	1.3	1
2 in. solid round	9	6	5
3 in. solid round	22*	14	11
4 in. solid round	....	27	22
5 in. solid round	....	46*	38
6 in. solid round	....	....	60
7 in. solid round	....	....	92*

*Tests indicate that the area of contact encountered is the maximum that will allow the blade to emerge without adhering to the metal being removed, when all rim heat is dissipated each in revolution for the entire duration of each cut.

On sections where the length of contact is shorter, the blade will stand a higher feed pressure without excessive heating. This permits operation of the main motor at higher loads on smaller sections, provided the duty cycle does not cause excess motor heating.

Table II is for machines having adjustable pressure feed which allows the blade to move in a horizontal direction, and to contact the material on the lower front arc. This allows the material to be rested on a horizontal table and against a front barrier. The resultant pressure

of the blade is at an angle below the horizontal. This eliminates the necessity for clamping the material when lying at right angles to the plane of the blade, provided that the bottom of the blade is below the table surface. On most rolled steel sections, where the mass of metal is distributed through a large area, the maximum length of contact is considerably shortened by this method, because of the diagonal arc of contact. Adjustment of the horizontal feed pressure to a constant value allows the blade to advance through each section as fast as it can remove metal. The rate of feed varies inversely with the length of contact, being faster and more efficient where the contact is shorter, and slower and less efficient where the contact is longer.

The rate of feed also varies directly with the blade pressure, which is greater than the horizontal pressure against the blade center, and which increases as the angle of contact increases below the horizontal. The blade pressure is greatest where the contact surface is just above the table.

The motor load is dependent solely on the blade pressure and therefore varies with the change of pressure angle.

With constant horizontal feed pressure, a thin flat plate is cut with uniform length of contact with highest blade pressure and motor load, but of uniform value for the entire cut. If the plate is held at a higher horizontal level, the length of contact is shorter, and consequently more efficient, but the blade pressure and motor load will be uniformly lower.

For irregular shapes such as I-beams or channels, resting on the table surface, the motor load will vary directly with the change of pressure angle as the blade progresses through the section, and will always be greatest at the finish of the cut. The cutting time is therefore dependent upon the average motor load, average length of contact, and the section area.

The blade will stand a higher pressure and motor load where the length of contact is shorter than the maximum safe limit. Since many sizes of structural shapes may be cut in this manner, with short maximum lengths of contact, it is possible to drive the blade with more power than can be used when cutting solid sections of the same area, where the maximum contact is longer.

The handling time between cuts is usually as long or longer than the cutting time for most structural shape cutting, and this permits operation of the motor at loads which are higher than rated capacity, without excess heating. The motor and driving assembly must have sufficient mechanical strength and proper electrical characteristics to withstand such loads.

The cutting times shown in Table II represent average values for various sizes of blades when operated with:

1. Average motor load not over 130 per cent of rated capacity.
2. Peak motor load not over 200 per cent of rated capacity.
3. Duty cycle not over 50 per cent of total cycle time.
4. High efficiency of power transmission from motor to blade.
5. Constant speed motor with sufficient pull out torque

Figure 4 — This view of the cutting operation is taken from the rear of the saw.

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Figure 5 — As the piece is cut, it is moved to a conveyor which takes it away. The piece shown on the conveyor is actually two pieces, but the cut is so square that it can hardly be seen.

TABLE II

Cutting data for machines providing constant horizontal pressure to blade arbor giving a higher blade pressure which will vary with angle of contact below horizontal.

Blade diameter, inches	24	46	48	56	58
Blade thickness, inches	5/32	1/4	9/32	3/8	3/8
Blade rpm	3500	1750	1750	1750	1750
Motor rated, hp	10	30	40	75	125
Motor average hp while cutting	13	39	52	97.5	162.5
Average cutting time in seconds for size section below:					
8 in. x 25.5 lb I-beam	46	21.1	17.3	11.5	6.9
12 in. x 55 lb I-beam	.....	47.2	38.7	25.8	15.3
18 in. x 70 lb I-beam	.....	.....	48.8	32.5	19.4
24 in. x 100 lb I-beam	.....	.....	.....	42.0	28.1
8 in. x 13.75 lb Channel	24.3	11.1	9.1	6.1	3.7
12 in. x 30 lb Channel	.....	24.8	20.5	13.6	8.2
15 in. x 50 lb Channel	.....	.....	34.6	23.0	13.8

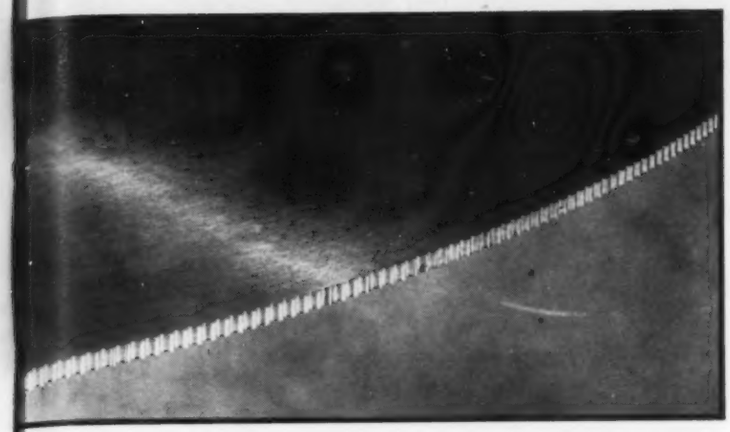


Figure 6 — The blade used in the saw shown in the previous figures is a hobbed blade of medium carbon content. ↑

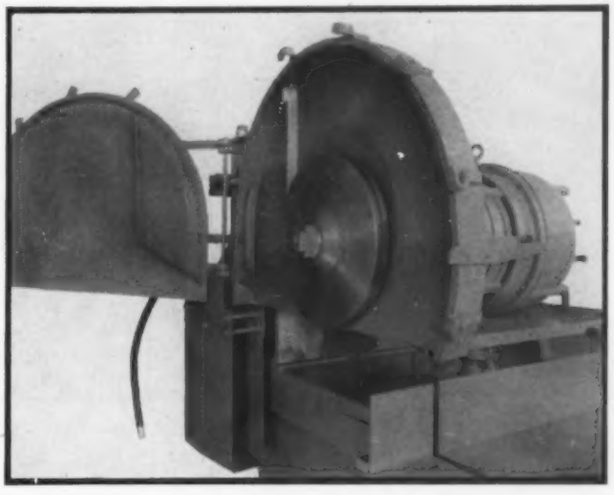
Figure 7 — Blades are cooled by an adjustable water head similar to that shown. →

to maintain the blade rim velocity as uniform as possible at loads varying from 100 to 200 per cent of rated capacity.

Figure 2 shows a 58 inch, 125 hp horizontal stroke friction saw with stock handling attachment used for cutting 40 foot stock lengths of steel tubing, 10¾ inch outside diameter with 5/16 inch wall thickness, into lengths of 38 in. for the manufacture of 250 pound bombs. When the machine is empty, the chuck carriage is drawn back far enough into proper position to receive the stock piece from the skids to the front of the machine. A trip releases one stock piece to roll onto loading saddles. The carriage moves forward and the chuck grips the back end of the stock and lifts it above the nearer saddle. As the carriage advances the tube forward, the tube is raised from the other saddle by the conical opening of a work centering ring, and advances on to position against a gauge stop set for the desired length. The blade is advanced through the tube, as shown in Figure 3, with a cutting time of 10 seconds. Note the brilliant throw of sparks, with some still adhering to the lower arc of the blade. The cooling water head is nearly 180 degrees from the point of contact and cannot be seen. This removes heat from the rim and allows it to sever the tube without any red heat showing on the part of the rim immediately above the tube. Figure 4 shows another cut being made as viewed from the rear. When the piece is severed it drops through a short distance onto the dumping saddle which removes it to ways where it can roll to the point where the burr is removed. The blade is hidden by the spark shield but the brilliant display of sparks can be seen. Figure 5 shows another view of the entire machine with the blade about to finish severing another piece. Note the complete absence of red heat on the portion of the blade rim immediately above the point of contact. Also note the two pieces on the conveying rolls. The sawed ends are so square that the point of separation cannot be seen. All operations are controlled from one position by one operator, except for the removal of the finished pieces to the conveyor and removal of the short length of stock after the last cut is made. This is done by the operator's assistant shown in Figure 3.

The handling time between cuts is also ten seconds, which permits severing each stock length at the rate of three pieces per minute. When the last cut is started, the chuck carriage releases the short end and starts back through its full travel and is about at the end of its travel when the last piece is severed. The assistant signals the operator for correct positioning of the carriage to receive the next stock length. Another cut is started on the new stock length in about one minute after the last cut of the previous stock length has been completed.

These action photographs illustrate the tremendous



production capacity of one friction saw where one size of material is to be severed to one finished length.

The material being severed in this case is of medium carbon content and requires the use of the hobbed blade as shown in Figure 6.

The blade is cooled by means of the adjustable water head shown at the rear of the open saw hood of another machine in Figure 7. Water is transmitted through the connecting flexible hose at the rate of 70 gpm at a pressure of 150 psi.

Figure 8 shows a 56 in.-75 hp horizontal stroke friction saw with storage skids, conveyor rolls and length gauge, which permit rapid conveyance of material to and from the machine.

One hobbed blade handles the entire day's large volume production cutting of many varied structural shapes in this large modern steel warehouse. At the end of the day's run, the blade is removed for hobbing and is replaced by another which has been rehobbed. Each blade is redressed as often as 60 times before finally becoming too small for further service.

Figure 9 shows the rear view of the same machine. The exposed trough with baffle plate strains all chips and sediment from the cooling water which is recirculated by the centrifugal pump.

Figure 10 shows the hobbed blade mounted on a 48 in.-50 hp machine in conjunction with a special fixture built for this particular cast steel sprocket wheel. The riser is removed at exactly the desired height and practically eliminates the necessity for subsequent grinding. The floor to floor time for each casting is 40 seconds. Each blade can cut a good many castings in

each day's run at very low cost per cut. But the savings in grinding wheels alone paid for this entire equipment in six months time.

Figure 11 shows another hobbed blade on a 36 in.-40 hp downstroke saw with special fixture for supporting a rear axle housing in either of two required positions, while the hollow ends are severed to the exact length required. One machine handles the entire volume production cutting of this part.

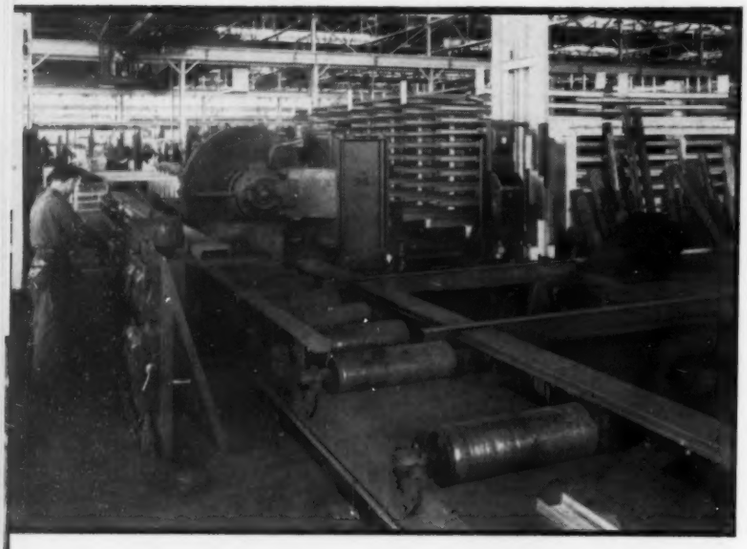


Figure 8 — This 56 in. 75 hp saw is used in a structural warehouse.

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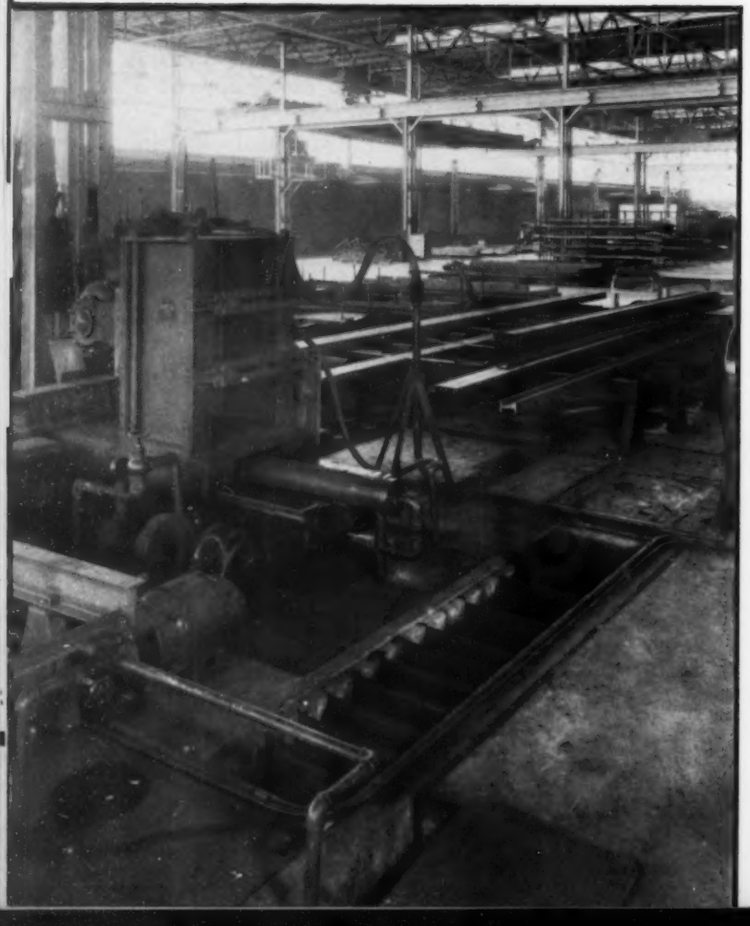
Figure 9 — This rear view of the saw shown in Figure 8 shows the trough where chips and sediment are removed from the recirculated cooling water.



The machine shown in Figure 8 is being used by many railroads for the reclaiming of railroad rail which has been damaged only at the ends where it has been in contact with the angle bars. This process consists of friction sawing the damaged ends and redrilling new holes at a cost about equal to the value of the scrap ends. The balance of the rail is known to be of good material and can be replaced in the system. The lengths severed from each end are half the length of the angle bars which are either 24 or 36 inches long. By relaying reclaimed rail in the entire system, only 10 per cent new rail is required.

Let us consider a modern friction saw as used by an American railroad for reclaiming railroad rail ranging in size from 80 to 130 pounds per yard and equipped with 48 in. diameter, $\frac{9}{32}$ in. thick, smooth rim blade. It is directly driven by a 75 hp, 1750 rpm motor with a constant pressure feed system for advancing the blade through the rail. The rails are conveyed by power rolls, one at a time, to position for cutting on the saw table, so that the portion which has been damaged in service will be severed from each end of the rail. This requires two separate cuts per rail together with the handling time of moving the rail to position. The total cycle time per rail is one minute, or 60 rails per hour.

For average size rail of 90 pounds, the cutting time is 13.8 seconds with full load of 75 hp on the driving motor. Because of the idling time between cuts, the motor may be operated at a higher load than full load. With a load of 97.5 hp or 130 per cent of rated capacity the time is 10.6 seconds per cut. The saw blade is redressed during the noon hour and operates through four hours in the afternoon and another four hours in the next morning. With two cuts per minute, the blade makes 960 cuts per blade dressing. At the end of each run, the blade is rough on the rim and only slightly deformed and is readily redressed by a lathe tool moved across the face of the rim when rotating at slow speed.

The same blade is kept in service until eventually too small which occurs after 70 redressings, or 67,000 cuts, on rail averaging 8.83 square inches per cut, or about 593,000 square inches.

During the cut, the rail is lying on its side on a horizontal table surface with the ball resting against a front barrier without being clamped. The initial blade contact is at the upper rear side of the base flange, and the average length of blade contact is thereby maintained at a minimum of 1.32 inches as the blade advances through each cut.

The sawed surfaces of each rail are hardened by the process to a depth of about 0.015 in. because of the high carbon content of 0.90 per cent. This is not objectionable for this service, as there is no record of a rail failure occurring from a progressive crack starting in from the end of any rail reclaimed by this process.

Figure 12a is a photomicrograph taken at a magnification of 200 diameters at right angles to the sawed face of the center of the ball of a 131 lb R. E. rail where the length of contact was $2\frac{1}{8}$ in. long. It was sawed with a 60 in.-125 hp machine in twelve seconds. The very dark area shows the normal structure of the rail. The lighter area shows the structure in the hardened

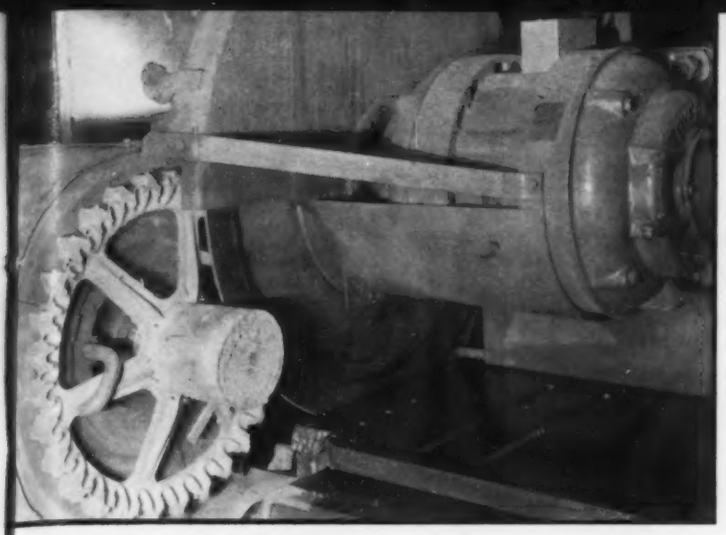


Figure 10 — A 48 in. saw is mounted in conjunction with a special fixture built to remove the riser on a cast steel sprocket wheel.

Figure 11 — Another mass production application of friction sawing is here shown where a 36 in. saw is used to cut the ends on rear axle housings.

zone, which extends 0.0125 of an inch from the sawed face.

Figure 12b is a photomicrograph taken at a magnification of 50 diameters at right angles to the sawed face of 12 per cent chromium stainless steel. The section sawed was an oval shaped riser of a casting measuring about 3½ by 4½ inches. It was severed with a 48 in.-35 hp saw. The photo was taken at a point near the center where the length of blade contact was about four inches. It shows the depth of hardness to be 0.050 of an inch.

Figures 12c and 12d are photomicrographs taken at a magnification of 100 diameters at right angles to the sawed face of a S. A. E. 52,100 steel. The section shape was 5 9/16 inch outside diameter with 9/16 inch wall which was severed by a 60 in.-125 hp friction saw in nine seconds. As the blade progressed through the section with constant feed pressure, the rate of feed was slower where the length of contact was greater. The fastest rate of feed occurred when the blade was half way through the section where the length of contact was that of the two walls or 1⅛ inches. Figure 12c shows the depth of hardening to be 0.0075 of an inch at this half way point where the rate of feed was fastest. Figure 12d was taken at a later point where the longest length of 3⅜ inches occurred, as the blade rim came into contact with the inside wall, and the rate of feed was slowest. This shows the depth of hardening to be 0.030 of an inch.

It will be noted from these photomicrographs that the depth of heat penetration in the sawed faces is very shallow, even where the blade approaches the limiting length of contact at which cutting ceases. The depth of heating at the sides of the blade is apparently the same as at the front of the blade. This has been determined from partial cuts where the blade has been quickly withdrawn from contact.

The efficiency of cutting, for a given width and condition of blade periphery, is greater where the length of contact is shorter and the rate of feed faster, because the depth of heat penetration into the body of the material is less. The efficiency decreases as the corners of the blade periphery become rounded to a larger radius, because this rounding increases the surface area on which heat is being generated.

For most efficient sawing, the blades should not be allowed to become excessively rounded on the corners, and all sections should be severed in such a manner that the average length of contact is as short as possible.

The sawed surfaces of all cold steel sections cut by friction sawing will be subject to sudden heating and rapid cooling practically equivalent to quenching. The hardness developed is dependent entirely upon the carbon and alloy content of the material. But the depth of hardness on high carbon or alloy steels is very shallow. The hardness developed is of course completely removable if the pieces severed are to be followed by heat treatment. In such cases, a saving in material cost is often obtained by purchasing such materials in their unannealed condition.

THE PAST HISTORY

The history of friction sawing apparently begins with a letter dated February 3, 1823 published in Volume VI of the "American Journal of Science and Arts" which attracted attention in this country and abroad.

This letter was written by Rev. Herman Daggett of Cornwall, Connecticut, to Prof. Benjamin Silliman of Yale College telling of the experience of a local cabinet maker by the name of Barnes, in connection with repairing a cross cut saw of very hard plate.

He had heard that the Shakers sometimes used a "buzz" to cut iron. He therefore made a circular plate of a piece of soft sheet iron stove pipe, fixed an axis to it and put it in his lathe, which gave a powerful rotary motion. While in motion he applied a common file to make it perfectly round and smooth, but the file was cut in two, while the plate received no impression. He then applied a piece of rock crystal which had the desired effect. He then brought under it a plate, which in a few minutes was neatly and completely cut through longitudinally. When he stopped the disc he found it had received no wear and he immediately applied his fingers to it without perceiving much sensible heat. During the operation there appeared a band of intense fire around the "buzz," continually emitting sparks with great violence. He afterward marked the saw for the teeth and in a short time cut them out by

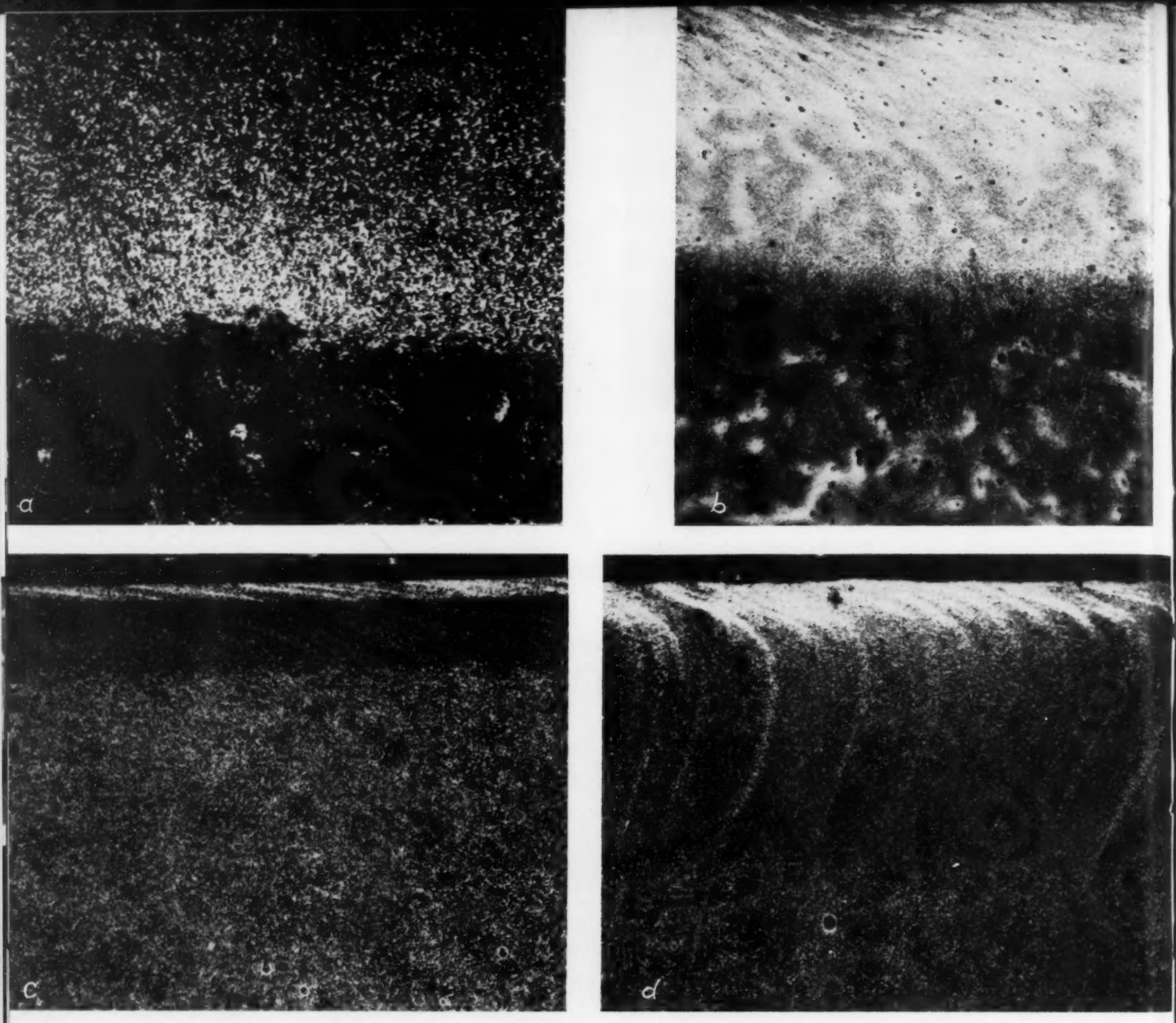


Figure 12 — These four micrographs show the effect of friction sawing on the structure of several steels.

the same manner. It seemed to him that the disc never came in actual contact with the plate. Mr. Daggett raised the question whether the fire was the electric fluid.

In 1824, Messrs. Darier and Colladon conducted experiments at Geneva, Switzerland, with a 7½ in. soft iron plate and found the critical speed to be between 34 feet 5 inches and 34 feet 9 inches per second. At higher speeds up to 70 feet per second the disc was only slightly attacked, and at speeds above 70 feet per second the disc was unaffected.

These experiences and those of many others through 1905 are excellently recorded in an article entitled "The Toothless Cold Saw" by Mr. E. D. Sewall in Iron Age, volume 76, pages 1676-8.

In volume 101, page 43 (1906) of "The Engineer" there appeared an article commenting on Mr. Sewall's report. This brought comments from Mr. P. V. Vernon which were printed in volume 101, pages 71 and 121 of "The Engineer," and these offer a possible explanation of the action.

In 1908 an article by F. W. Harford entitled "The Action of Toothless Circular Saws" was printed in "The Engineer," volume 105, page 181. This article is illustrated with photographs taken at high magnification of the samples of the disc, kerf, and bar; and reveal that the depth of heat penetration does not extend more than 1/100 to 1/150 of an inch from the sawed faces of section cut with a badly deformed blade.

On September 25, 1930, Mr. A. B. Pearson of Munhall, Pennsylvania, presented a paper at the fourth national iron and steel meeting at Chicago, Illinois, of the American Society of Mechanical Engineers entitled "Design and Construction of Hot Saws for Cutting Heavy Sections." This paper very ably presents the problems involved in the high speed hot and cold sawing of the larger Carnegie beams, and illustrates enlarged views of the chips obtained from both processes.

DISCUSSION

PRESENTED BY

N. A. MALONE, Industrial Engineer, The Manufacturers Rubber and Supply Company, Akron, Ohio

J. M. LEWIS, Consulting Engineer, Kling Brothers Engineering Works, Chicago, Illinois

S. C. READ, Master Mechanic, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

G. E. STOLTZ, Manager, Steel Mill Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania

C. M. MYERS, Electrical Engineer, Youngstown Sheet and Tube Company, Youngstown, Ohio

L. E. BIBER, Engineer, U. S. Steel Supply Company, Pittsburgh, Pennsylvania

WILLIAM BOYD, Superintendent, Structural Finishing Mills, Weirton Steel Company, Weirton, West Virgina

N. A. Malone: I realize that friction sawing is limited in application. However, we have these problems: "What can be done to cope with the steel metallurgist's and customer's acceptance of a friction sawed surface?"

I would also like to ask Mr. Lewis, what progress has been made in the establishment of a definite operating technique to cope with problems, such as, the proper selection of the synchronizing of feeds and speeds to obtain a desirous resultant surface with a friction saw cut.

J. M. Lewis: The prospective user of friction sawing must determine whether the heating effect, on the sawed surfaces of the steel, will present any problem regarding subsequent work which that material must perform, or which must be performed on it.

The illustrations show that heat penetration is shallow, and is below the melting temperature. Hardness cracks are apparently absent, and the grain structure is refined. The degree of hardness is dependent on the carbon or alloy content of the material. If sawing is to be followed by heat treatment before machining, any hardness present will be relieved.

The variable depth of hardness obtained with constant pressure feed is not objectionable. This feed method has the advantage of permitting uniform load on the driving motor with resultant uniform blade rim velocity. These important advantages might not be retained if the feed were synchronized to provide a positive rate of feed, which could produce a uniform depth of hardness. Constant pressure feed provides the simplest possible operating technique, as the same pressure is used for any section to be cut, within capacity of the machine.

N. A. Malone: I have observed that a high carbon content seems to be an asset in efficient cutting, due to the fact that a high carbon content readily combines with oxygen, which is an aid to oxidization.

I might add, for those who are interested in cutting steels, subject to heat checking, experience has proven that slow cooling by burying in a heat conductor material has eliminated heat checks.

Getting back to the technique of operation, Mr. Lewis, I noticed that some saws illustrated displayed a much smaller driving flange than others. Is this to control vibration of the blade? Also, I am wondering whether in the selection of your feed, depending on the characteristic of the steel high or low in carbon content, what have you done in the selection of a general purpose feed to cut certain steels. I presume you have a constant peripheral speed.

J. M. Lewis: Satisfactory friction sawing may be obtained on any high carbon steel with a smooth blade rim because the rim becomes roughened on such steel. On low carbon steel, the smooth rim does not roughen, and the blade periphery must be indented, in order to produce satisfactory friction cutting.

The friction sawing of cold steel requires the generation of heat on the contact surface at a faster rate than that surface can absorb heat. With proper side clearance, heat is concentrated on the contact surface immediately ahead of the blade, and sidewise only at the blade rim corners. The depth of heat penetration ahead and to each side is dependent on the rate at which the blade rim advances. The large difference in temperature between the heated side surface, near the blade rim, and the cold metal in back of the surfaces, permits rapid cooling of each succeeding portion of these surfaces as the blade progresses through the cut. This sudden cooling will cause hardening of the sawed surfaces if the steel has sufficient carbon or alloy content to receive a hardness. The hardening action is progressive with advance of the blade and cannot be prevented when sawing cold steel. This sudden quenching does not occur when steel is sawed while red hot.

The saw driving flanges must provide sufficient support to center the blade accurately and to rotate it in a true plane. The portion of the blade which projects beyond the flanges must have proper balance and sufficient tension to also rotate in a true plane. The diameter of the flanges may be as large as the arbor bearings, driving pulley guard, or driving motor. The projection of the blade beyond the flanges, pulley guard, or motor, must be sufficient to sever the largest section of material within the capacity of the machine.

The same constant pressure feed serves equally well for any size of steel section whether high or low carbon content, so long as uniform motor load and blade rim velocity can be maintained.

N. A. Malone: I noticed on all your slides demonstrating cutting, that all materials being cut were ferrous metals. What have you done on the friction cutting on non-ferrous metals?

J. M. Lewis: The friction saw removes metal from the heated contact surface of any metal section whose grain structure will not break down, and which metal will lose sufficient tensile strength to break away from contact with the colder metal beneath, without reaching a melting temperature.

Of the ferrous metals, all steels are readily severed in this manner. The grain structure of cast iron breaks down on the contact surface before it can be heated sufficiently to lose tensile strength. Therefore the metal is removed purely by an abrasive action, without very satisfactory results.

Of the non-ferrous metals such as bronze, aluminum, or copper, their contact surfaces do not reduce in tensile strength sufficiently to break away from contact without melting. Consequently the metal being removed brazes very readily to the warm steel blade rim before it can

emerge from contact. The results are not very satisfactory up to the present time.

S. C. Read: In our round mill we have a downcut saw on which we find it essential to use the correct speed. Several years ago we were getting a heavy burr at the bottom of the cut, and on checking the speed it was observed to be 12,000 feet per minute. We changed the design, increased the speed to 21,000 fpm and now get only a slight burr.

We ran into one difficulty in making the change; the saw was mounted on an arbor with a V belt drive, and in the early days it had a babbitt bearing. We wanted to change to a non-friction bearing. In checking with the bearing designers, they were a little afraid that the arbor speed was too high. One manufacturer furnished a bearing, and the bearing has been very successful and has given no trouble. During the war, bearings were hard to get and we bought on the market a bearing of the same size, installed it and within 24 hours we had a failure. In later checking, we discovered trouble developed in that the stock bearing had not sufficient clearance and became hot.

This saw, which is a hot saw, has a shaped tooth and as the teeth are symmetrical, it can run in either direction. After a period of operation we will frequently find a radial crack, and if the crack is not too deep we can drill a 5/16 in. hole at the bottom of the crack and continue using the saw.

After changing the speed and design it has given excellent results.

G. E. Stoltz: Naturally we in the electrical industry are interested in the motors used to drive these saws. I noticed most of the photographs shown by Mr. Lewis used direct motor drive although one must have been a V belt drive because the motor was mounted at the back. We have worked on the applications of some of these saws, and we have found it sometimes difficult to directly connect the motor to the saw due to the fact that the thickness of the material to be cut was such that it limited the diameter of the motor, and a special arrangement had to be adopted. In one case it was necessary to reduce the diameter of the motor to such an extent that a double motor had to be applied.

I would like to ask Mr. Lewis about the feed. The peripheral speed of the face of the saw is critical. No doubt it can be rather easily selected and after that has been done, the proper motor applied to maintain that speed. However, it isn't clear to me as to how you select the rate of feed, and I would think that would be some problem and one that the operator might or might not properly choose.

As Mr. Lewis has stated, heat is generated by the saw passing through the work at a given speed and pressure. If the saw isn't fed in fast enough you approach the point, where too little heat is generated so that the material may carry the heat away and the metal will not reach the temperature desired.

In the application of a toothed saw, it has been our practice to put a relay in the control that causes the feed motor to draw a given amount of current, and that in turn means that the saw maintains a fairly constant pressure against the material. I imagine the same thing can be done in this case, but I think the operator would have to be more careful than in the past in selecting the right value of pressure for different materials. I would be very glad to have Mr. Lewis explain this part of the operation.

J. M. Lewis: The desired electrical and mechanical requirements for the driving motors are set forth in the descriptive data, accompanying Tables I and II. All friction sawing machines, when arranged with adjustable pressure feed systems, permit the selection of one value of constant pressure to suit the load desired on the blade driving motor. If this one pressure setting is sufficient to develop full load on the driving motor, the blade will then sever any size or shape of steel section within the machine's listed capacity.

The load imposed on the driving motor is constant if the blade stroke is directly towards the contact surface as shown in Table I. The motor load will be variable within acceptable limits as shown in Table II, where the direction of blade contact is not in line with the direction of blade stroke.

G. E. Stoltz: What I had in mind, Mr. Lewis, concerns varying sections. Suppose an I-beam or channel is being sawed, more material may be cut one time than another. Would it not be necessary to vary the pressure as the length of contact is changed?

J. M. Lewis: It is not necessary to vary the feed pressure. It actually is an advantage to maintain constant feed pressure, for all friction sawing, because it permits a more uniform load on the driving motor.

The load imposed on the driving motor of any type of saw is dependent upon tangential resistance to blade rotation.

In friction sawing, the blade action differs from other sawing methods because the tangential resistance is dependent on total radial blade pressure but is independent of the length of blade contact.

In other types of sawing which depend upon the thrust of a series of sharp edges to remove succeeding layers of contact surfaces, a minimum feed per tooth is necessary to prevent excess tooth heating and rapid dulling. This is true for all slow-speed sawing of machinable steels, or high speed sawing of soft, non-ferrous metals and wood.

For such sawing a minimum rate of feed is desirable for maximum lengths of blade contact, and a retarding action is necessary to prevent excessive feed per tooth on short lengths of contact. The tangential resistance is definitely dependent upon the number of teeth in contact, the depth of feed per tooth, the sharpness of the cutting edges, and the strength of the material surface being removed. These factors obviously affect the load on the driving motor and the type of feed must be suitable for many more variable factors than are encountered in friction sawing.

N. A. Malone: In designing a cold sawing machine, we encountered the same problem, in a saw whose operation was based upon the down cut and controlled feed principle, and operated hydraulically.

When cutting a round section, the saw would have a tendency to slow down when the blade reached the maximum diameter of the section, due to the increased number of teeth in contact with the sectional area of the material. To maintain cutting efficiency, we eliminated this condition automatically although by hydraulic, and not by electrical means. Thus we maintain a constant feed per inch throughout the material.

G. E. Stoltz: I spoke of using a relay in the control of the forward motion motor. You might also use a relay to control the saw motor.

N. A. Malone: That is right.

J. M. Lewis: In slow speed sawing the blade driving motor may be subjected to exceedingly variable loads with constant pressure. In high speed friction sawing, the variation of load imposed on the driving motor, may readily be maintained within acceptable limits with one value of constant feed pressure. If the variation of motor load was beyond such limits, it would be necessary to reduce the feed pressure, when the load on the driving motor became excessive. If the friction saw feed system permits the selection of one proper value of feed pressure, it is not necessary to allow reduction of pressure with increasing load on the driving motor.

The pressure should be adjusted to a value which will allow a limited maximum value of load on the main motor at which it will continue to drive the blade at nearly constant speed.

Excessive pressure adjustment would permit excessive motor load and excessive reduction of blade rim speed, which, of course, must be avoided.

C. M. Myers: Mr. Lewis, since you brought up the question of critical speed and since you want to maintain the speed constant, most of the installations I have seen have used an induction motor. Would a synchronous motor obtain that constant speed better than an induction motor?

J. M. Lewis: It might. There are a good many mechanical problems involved. The squirrel-cage induction motor provides satisfactory operation with the slight drop in its speed-load characteristic which is safe for blade operation so long as the maximum load is not too excessive. For instance, in the hot sawing of material I think many of you have probably noticed a condition where the blade may drop down to nearly half speed. Such excessive sudden changes of rim velocity should be avoided. Rapid deceleration develops a tremendous force on the blade rim which might very possibly exceed the stress which that rim can withstand. A strain crack can occur.

Uniform velocity is very much to be desired on any process of high speed sawing, I would say it is probably the most critical and important part of friction sawing.

L. E. Biber: Mr. Lewis, did I understand you to say that you could cut down the fin in cutting structural shapes by perfect hobbing or perfect sharpening of a saw? Does such sharpening minimize or cut down entirely the fin in cold sawing?

J. M. Lewis: There will be a burr on every piece of material severed by friction sawing. The amount of burr produced on the severed edges of any given rolled steel section depends upon three known factors, namely, the length of contact, the cutting time, and the condition of the blade periphery. The burr is less where the length of contact is short, and is more where the contact is longer. If the same section is cut faster, the amount of burr at all points will be less. If the corners of the blade periphery, as formed by the tops of the teeth and the sides of the rim, are sharp, the amount of burr will be at a minimum value for that given time rate of cutting.

If the machine has capacity to generate heat on the maximum length of contact at a rate which is much faster than actually required, and the total cutting time is very short, and the blade is properly cooled, a minimum amount of burr can be maintained for several hours of operation.

L. E. Biber: Has there been any experimentation to eliminate that burr? You know that is a big factor in cutting. Maintaining a crew to do the chipping after the sawing is done to remove the burr, is of course a labor expense. I have heard that someone was making experiments in which they were shooting a jet of oxygen against the metal as it was being sawed. Since the fin is the hottest part of the metal it would oxidize with the oxygen and thereby eliminate the fin. Do you know of any such experiments being done?

J. M. Lewis: Yes, I know of such experiments. Some reduction of burr is claimed while cutting thin flat material, requiring a uniformly short length of blade contact, by injecting oxygen into the air stream at the blade periphery immediately ahead of contact with the material. It is very difficult to prove its value on irregular rolled steel sections, because of the shifting of the initial point of contact on the blade periphery.

William Boyd: We use an oil hydraulic feed at 100 pounds pressure, and saw at a peripheral speed of 24,000 feet per minute. However, I don't think Mr. Lewis sufficiently stressed the importance of cooling the blade. For instance, in the photographs, there is a spray block on the rear of the saw case which has two ¼ in. jet holes. He did say that they used 70 gallons of water a minute at 150 pounds pressure. We add to the hydraulic water spray in the back and incorporate one on the front of the shield, immediately above the end of the case, so that there are four sprays on the blade at all times with an hydraulic pressure of 500 pounds. In addition to that, we install three sets of wooden baffle plates, inside the case, that are flush with the blade and they trap the water in the case, so the blade is practically submerged in water during the whole operation. The advantage to this is that you don't get the red streak on the peripheral face of the blade when it is sawing which means maintaining a sharp edge and practically eliminating burrs. The life of the saw then, as you can realize, is indefinite.

J. M. Lewis: The answer to proper sawing is complete heat dissipation from the blade rim at some point of the periphery after emerging from contact, so that the rim will not accumulate heat during succeeding revolutions, but will remain cold for the entire duration of each cut. There are various methods by which water can be forced effectively into contact with the blade periphery. Many users of friction saws have learned how proper cooling can greatly increase the life of the blade between redressings. There are still many users who assume they are cooling the blade by directing one or more streams of water towards the blade rim. Frequently this water does not penetrate through the air stream to actually strike the blade at all.

William Boyd: I might say we have discovered, with ordinary city or tank pressure of water the blade cannot be sufficiently cooled as the speed of the blade creates a vacuum, and without sufficient pressure the water will not penetrate this vacuum. The blade then runs dry, and although you may think that you have water on it, it doesn't touch the blade at all.

By-Product Coking

. . . . the following two papers outline the development of the coke and by-product industry . . . . the first paper concentrates on the development and history of the industry in the Niagara frontier, while the second paper discusses the by-products which make the process economic . . . .

by Robert W. Pugh and Edward V. O'Neill

SUPERINTENDENT OF COKE OVENS
BETHLEHEM STEEL COMPANY
LACKAWANNA, NEW YORK

SALES MANAGER.
DONNER-HANNA COKE CORPORATION
BUFFALO, NEW YORK

COKING INDUSTRIES IN THE NIAGARA FRONTIER

by ROBERT W. PUGH

▲ THE coking industry in the Niagara frontier, as elsewhere throughout the country, has been associated very closely with the iron and steel industry. Blast furnaces and the iron industry became established in this section long before there were any coke producing facilities in the area.

In 1881, one of the four blast furnaces located in this area was rebuilt and converted into the first coke-fired furnace in New York. By the turn of the century four of the five furnaces in operation at that time were coke-fired.

Despite the need for coke for the blast furnaces and foundries located here in the early part of the century, no reference is present to any coke ovens being established here to meet those needs. It is logical to assume that there were none. In 1893 all of the furnace coke made in the United States was the product of beehive ovens, the only product of which was coke. The yield from coal to coke was approximately 65 per cent. With no coal deposits in the proximity of the Niagara frontier, there was no economic advantage in transporting 100 lb of coal from the distant mines to produce 65 lb of coke near the point of consumption.

The first by-product ovens for the manufacture of blast furnace coke in America were Otto Hoffman ovens, built in 1894 at Johnstown, Pennsylvania, for the Cambria Steel Company. Unlike the old beehive oven, the by-product oven plant produced coke for the iron industry and domestic use, and produced gas for use in steel mill soaking pits, open hearth furnaces and other industrial or domestic use. In the early plants, tar and ammonia were also recovered. As more knowledge was gained benzol, toluol, xylol, solvents, etc. were added to the list of products.

With the introduction of the by-product oven, the answer to the problem of locating coke producing units reversed itself. The economical location of the beehive oven was at or near the mines. In most cases, the

Presented before AISE Buffalo District Section Meeting, November 13, 1945.

economies were in favor of building the by-product oven plant in the vicinity of the blast furnaces, particularly where these were operated in conjunction with a steel mill.

Compared to a modern coke oven plant, these early plants were crude and inefficient; neverthless, they were so far ahead of the beehive oven that less than 10 years after the first installation at Johnstown, Pennsylvania, plans were being laid to establish on a large scale, the steel industry, and along with it the coking industry in the Niagara frontier.

In 1899, the Lackawanna Iron and Steel Company decided to move their 60 year old iron and steel plant from Scranton, Pennsylvania to a site near Buffalo, in the present city of Lackawanna. In 1900 the building of the plant was started. The plans for the steel plant originally called for a coke plant of 20 batteries, with a total of 940 ovens, built in two lines of 10 batteries each, with the condensing plant, coal bins, etc. located between the lines.

Only one line, or 10 of these batteries for a total of 470 ovens was built. Four batteries of 47 ovens each were Otto Hoffman's and six batteries of 47 ovens each were Rothberg's. The Otto Hoffman ovens had vertical flues and were equipped with two common regenerators on each end of all batteries. They were the first ovens to be built with regenerators in this country. The Rothberg ovens had horizontal flues and were equipped with recuperators for recovering some of the heat from the waste flue gases. Each oven produced about six net tons of coke per charge. Seven of the ten batteries went into operation between May and September 1904, the eight and ninth in December 1906, and the tenth and last in March 1907.

This plant, with a capacity of approximately 950,000 net tons of coke annually, was the beginning of the coking industry on the Niagara frontier. In addition to producing coke, the original plant produced gas, tar and ammonium sulphate. In 1915 the necessary apparatus was installed to produce benzol, toluol, xylol and solvents.

From 1904 until 1917, this was the only coke plant in the district. In early 1917, the Semet-Solvay Company completed and placed in operation a coke plant located off the River road near the present Wickwire Spencer Steel Company plant in Tonawanda. The plant consisted of one battery of 60 Semet-Solvay horizontal flue ovens, the necessary coal-handling equipment and apparatus for producing gas, tar, ammonia as aqua ammonia, and light oil. The capacity of this plant was approximately 365,000 net tons per year. Upon the completion of this plant the coke producing capacity of the area was 1,315,000 net tons annually.

In 1920 three of the old Otto Hoffman batteries were shut down for dismantling and a new battery of 60 Semet-Solvay ovens produced its first coke at the Lackawanna Steel Company plant. In the same year the third producer of coke in the area first began operations, for in December 1920, the Donner-Hanna Coke Corporation placed in operation a coke plant on Abbey Street near the present Republic Steel Company works on South Park Avenue in Buffalo. The coke producing facilities consisted of three batteries of Koppers ovens, in which each battery contained 50 ovens.

Lackawanna Steel Company's new battery and the three batteries at Donner-Hanna, added to the capacity which existed after the retirement of the three Otto Hoffman batteries, brought the total capacity at the beginning of 1921 to approximately 2,140,000 net tons annually.

In 1922 the Bethlehem Steel Company acquired the interests of the Lackawanna Steel Company in Lackawanna and immediately started on a program of reconstruction and additions to the plant. Construction was completed and two batteries of 57 ovens each of the Koppers-Becker type were placed in operation during the latter part of 1924. Prior to the starting of the two new Koppers batteries the last of the old batteries was closed down, never to operate again. This construction made little or no change in the capacity of the plant or area as it was a replacement of old obsolete facilities with modern equipment.

In 1927 both Bethlehem Steel and Semet-Solvay increased their coking capacity. Bethlehem placed in operation their fourth battery, consisting of 57 Koppers-Becker type ovens. Semet-Solvay completed and placed in service their second battery, a 60-oven Semet-Solvay battery. These additions brought the capacity of the area to 2,965,000 net tons annually.

In August 1933, Donner-Hanna placed in operation their fourth battery, a 51-oven unit of Koppers-Becker type ovens. This raised the capacity of the area to 3,210,000 tons.

The next addition occurred at Bethlehem Steel Company's plant in Lackawanna. In August 1941, a 76-oven Wilputte battery pushed its first coke.

In 1943 the last ovens built in the area were placed in operation. Bethlehem started a second 76-oven Wilputte battery and Donner-Hanna a small battery of 15 Koppers ovens. The 1943 expansion brought the total coke capacity of the area to 4,135,000 net tons annually.

From the beginning of the coking industry in the Niagara frontier in 1904, each plant has made additions and alterations to their apparatus for production of coal chemicals to increase the efficiency as well as to keep abreast of the increased coking capacity.

Today the three coke plants in the Niagara frontier are: Bethlehem Steel Company with 6 batteries with a total of 383 ovens; Donner-Hanna Coke Corporation with 5 batteries with a total of 216 ovens; and Semet-Solvay Company with 2 batteries with a total of 120 ovens.

The grand total is 13 batteries with a total of 719 ovens.

During the year 1944, the three plants processed approximately 5,600,000 net tons of coal. From this, covering the major products only, they produced:

1. Approximately 4,220,000 net tons of coke.
2. 31,500,000,000 cu ft of gas over and above that required to heat the ovens.
3. 41,000,000 gallons of tar.
4. 40,000 tons of ammonium sulphate, in addition to that recovered as aqua ammonia which was the equivalent to an additional 12,000-13,000 tons of ammonium sulphate.
5. 7,650,000 gallons of benzol.
6. 1,170,000 gallons of toluol.
7. 220,000 gallons of xylol.
8. 235,000 gallons of solvent naphtha.

9. Approximately 4,000,000 gallons of light oil were shipped from the area to be processed into benzol, toluol, xylol and solvents.

MODERN COKE OVENS - THE BASIS OF A CHEMICAL INDUSTRY

by ***EDWARD V. O'NEILL***

▲ THE coke industry as it exists in the Niagara frontier is typical of the American coke industry in general in that the majority of all coke ovens in the United States were built to supply coke to blast furnaces, and continue to operate for that primary purpose. In 1943, the last year for which complete figures are available, 80 per cent of all coke produced in the United States was consumed in blast furnaces, the balance being distributed for foundry, domestic, and miscellaneous industrial use, including the manufacture of producer and water gas and non-ferrous smelting. While the requirements of the iron and steel industry in 1943 were abnormal due to the war, it is true that coke production follows closely the trend of the iron and steel industry.

The coke industry is relatively unpublicized and unknown, principally because the essentiality to the production of iron and steel keeps the industry in the shadow of the larger and more spectacular parent industry. In itself, however, the coking industry is far from small. It consumes 18 per cent of the annual production of bituminous coal in the United States, and bituminous coal is, of course, its principal item of cost.

Metallurgical coke is produced in two types of ovens. Originally, it was a product of the beehive oven which converted coal into coke and wasted the volatile matter into the air. The turn of the century saw the beginning of the replacement of the beehive type of oven by the modern coke oven, more generally known as the by-product oven. The designation "by-product" no doubt was originally applied to distinguish this oven, which recovers the volatile content of the coal charged, from the wasteful beehive oven. However, while it is correctly descriptive of an oven type, its use over the years has been extended to the products other than coke, produced by these modern ovens. Thus we find an annual Bureau of Mines' report published under the title, "Coke and By-Products." Actually, while coke may be the primary product for which a modern or by-product plant is contemplated, the construction of such a plant is not economically feasible unless there is a market for the products recovered in the operation. A modern coke plant requires a large capital expenditure, while the beehive oven is relatively inexpensive to build. Only the value of the products other than coke permits the heavy investment and resultant high fixed charges. This is obvious from the Bureau of Mines' estimate that the value of by-products recovered at producing plants exceeded $221,000,000 in 1943, and that of these products, breeze, gas, tar, and light oil had a calorific value equivalent to 21,500,000 tons of coal. Goods of that value are not found in any industry. Recovery of this value is part of the economic foundation on which millions of dollars are invested. All of these products would have been lost had the coke been made in beehive ovens.

These products, other than coke, divide themselves into four groups:

1. Gas.
2. Crude tar and its derivatives.
3. Ammonium sulphate and ammonia liquor.
4. Crude light oil and its derivatives.

We will attempt to deal briefly with the end uses of these products in the order named.

Gas — Other than coke, gas is the most important product of coal carbonization, judged by either value or heat content. The coking industry is by far the largest producer of manufactured gas in the United States and is an important factor in the distribution of gas to affiliated and neighboring industries, public utilities, and communities.

Of the total gas produced at a coke plant, approximately 40 per cent is used to provide the fuel requirements of the ovens from which it is evolved. If low Btu gas is available, it may be used for underfiring the ovens, thus releasing for sale or use, 100 per cent of the high Btu gas produced. Distribution of the available gas varies from plant to plant. In some instances it is entirely consumed in the adjacent steel mill; in others, a contractual obligation with a local public utility calls for delivery of a certain minimum volume per day, with the remainder being used by affiliated steel mills and other industries; or in some instances, all surplus gas is distributed through city mains. In the Buffalo district, we have examples of all three arrangements.

The importance to a community of a local source of gas, even if only to supplement natural gas, has been well proven in Buffalo during the war years when coke oven gas carried approximately 30 per cent of the total utility load at a time when limited supplies of natural gas were being used to the full extent available.

In passing, note should be made of the modern coke ovens operated by gas companies. They are definitely a part of the industry and are included in all current statistics, a though they place more emphasis upon the production of gas than upon the type and grade of coke obtained. Seventeen coke plants owned by gas companies which operated during 1943 contributed about 6 per cent of the total coke production of the industry.

Crude coal tar and tar derivatives — Since the majority of producing ovens are owned by, or affiliated with, the steel industry, it must be remembered that crude coal tar always has a minimum value to the producer as fuel. The steel industry consumes great quantities of liquid fuel and obviously cannot sell coal tar at less than its fuel value, which is approximately 10 per cent greater than heavy fuel oil.

In recent years considerable attention has been directed toward the more efficient utilization of tar by recovering its valuable components. Approximately 28 per cent of total production of crude tar is now processed

by coke oven operators, and in 1943 about 57 per cent of the total output was sold by producers for refining.

The most valuable derivative obtained from tar distillation is creosote, used principally for wood preservation and disinfectants. Another tar derivative is phenol, used principally in phenol-formaldehyde resins for plastics, molding compounds, and other synthetic resins. Phenol is also used in mixtures with cresol for refining lubricating oils; in the manufacture of dyestuffs, picric acid, and other chemicals; and in the preparation of medicinal products. Cresols, cresylic acid, and other derivatives broadly parallel phenol in end use. Cresol has not been successfully synthesized.

Road tar is another product of tar distillation, and its use and importance for surfacing vital and secondary highways is known to all travelers.

Ammonia — Approximately 85 per cent of the ammonia recovered by the coking industry is being produced as sulphate of ammonia and the remainder as ammonia liquor. It is estimated that the 1945 production of sulphate of ammonia will approximate 800,000 tons.

Ammonia liquor, with a nitrogen content of 24.6 per cent, is used to supply low priced nitrogen for mixed fertilizers. Coke oven ammonia liquor is also a source from which is derived ammonium hydroxide for use in the manufacture of textiles and rubber, as a condensation agent for resins, and as an accelerator in phenol condensation processes. It also is used in photography, various pharmaceutical preparations, soaps, and in a number of manufacturing processes.

Ammonium sulphate, similarly, enters into various manufacturing processes, among them the production of synthetic textiles, cellulose films, leather chemicals, ceramics, and fire proofing compositions.

The outstanding and extremely important use for sulphate of ammonia, however, is in the production of mixed fertilizers. The coking industry is the most important source of fertilizer nitrogen in the United States. There were long periods during the war just ended, when the only dependable source of fertilizer nitrogen was sulphate of ammonia, and during the entire period of strict allocation, this product was the keystone around which the nitrogen unit of War Production Board built its fertilizer nitrogen program. The success with which the coking industry fulfilled this important obligation is best indicated by the increased productivity of our farms during the war years in the face of reduced acreage and insufficient manpower. In peacetime, with other nitrogenous materials freely produced in quantities never before available, sulphate of ammonia continues in strong demand by the fertilizer industry because of its peculiar physical attributes. Ammonium sulphate is the only chemical nitrogen carrier available in quantity which can be used to produce high nitrogen content mixed fertilizers of good mechanical condition. It has a favorable influence on the condition of mixed fertilizers.

One of the most important of the recommendations of the Agricultural Research Administration of the United States Department of Agriculture is an increase of 20-30 per cent in the average plant food content of fertilizers. Sulphate of ammonia is ideally suited to supply the desired higher nitrogen content without entailing additional production and processing problems to the fertilizer manufacturer.

The coking industry also provides ammonium sulphate in bags in a dried and screened grade for direct use by the grower as a top and side dressing material.

Crude light oil and its derivatives — Light oil production at its war-time peak exceeded 250,000,000 gallons per year and in 1943 approximately 98 per cent of the total was refined by the producers. The products of fractional distillation are chiefly benzol, toluol, and xylol.

The latter, xylol, is recovered in relatively small volume, principally in industrial grade, and is widely used as a solvent in lacquers and varnishes, as a solvent for rubber cements, and in the production of waterproofing compounds. Finer grades available from selected producers are made for special uses on specific order.

Toluol, of course, is first thought of as the basic ingredient for the production of explosives of the TNT type. It was directed almost exclusively to ordnance uses during the war years and its usual chemical and diluent outlets were forced to use substitutes. The complete cessation of high explosives production, however, has released toluol into normal channels and it is again being used in the production of organic preparations, benzoic acid, lacquers, dyes, perfumes, saccharine, and as a solvent for gums, resins, and most oils.

Prior to 1941 most of the benzol recovered was produced as "motor grade" for blending with gasoline to improve its anti-knock performance. Benzol is an effective anti-detonant or knock-suppressor. Only a small portion of the total production was used by the chemical industry.

Benzol, however, was basically essential to so many of the programs on which our military success depended, that some six months after Pearl Harbor, it was put under the absolute and complete control of War Production Board by the issuance of a general preference order which specifically prohibited its use as fuel in internal combustion engines.

War Production Board then allocated benzol only for production of such critically essential materials as synthetic phenol, cumene for aviation gasoline, nylon, nitrobenzene, medicinals including DDT, and necessary organic preparations. This distribution, under the thorough and efficient supervision of allocating authorities kept important needs supplied but used all the nitration and industrial grades of benzol which the industry could produce. However, plans then under way for our synthetic rubber program culminated in a decision to produce a type of rubber subsequently called GR-S and the balance between benzol production and use proved to be only temporary. GR-S, or Government Rubber-Styrene, results from styrene, made from benzol, combining with butadiene, made from alcohol or petroleum, to produce the rubber.

Therefore, during the period when styrene plants were under construction, benzol allocation was drastically tightened so that all possible material might be stock-piled toward the rapidly approaching heavy demands for the rubber program. Large quantities were accumulated at strategic locations by holding all other consumption to irreducible minimums and by giving styrene precedence over cumene for aviation gasoline.

The latter program was continued by using other anti-detonants, including the addition to aviation gasoline of coke oven toluol. The styrene plants were completed on schedule and their operation drew heavily on both stock piles o benzol and the then current production of benzol. This pattern of benzol distribution continued for the duration of hostilities.

Among the chemicals brought into prominence by war and remaining to fill great industrial roles in peace are many which depend on benzol. Some are products whose major effect on our economy was being felt prior to the war. Some came into being under the pressures of war-time necessity.

The properties of the synthetic fiber called nylon were known to all when the product was withdrawn from civilian markets to fill important wartime roles. Nylon fiber is returning to the store counters of America in its many forms. There will be no reduction in the production of nylon with its peculiar ability to be formed into fibers and into various shapes such as bristles and sheets. Nylon continues its dependency on benzol which is today moving into nylon operations in bargeload quantities.

Many of the wartime uses of phenol are paralleled in our peacetime economy. Here again is a product, the production of which is increasing rather than decreasing with the end of hostilities. Production of synthetic phenol begins with the chlorination or sulphenation of benzol, and many millions of gallons of benzol are being consumed in the production of this essential chemical. The uses for phenol are many and varied, and outstanding among them is the part the phenolics play in the over-all plastics picture. Phenolic molding compounds, phenolic industrial resins, and phenolic oil-soluble resins provide a versatility on which has grown a great industry which will continue to new heights now that wartime restrictions are withdrawn. Plastics formed from phenolic molding compounds surround us in such common forms as our telephone casings, radio cabinets, and household appliance parts. They have provided utility with a new beauty. Phenolic industrial resins provide extreme toughness, moisture resistance, and moldability, while the oil-soluble resins are now being incorporated into many of the better quality paints because they speed up the time of setting, eliminate water spotting, and improve gloss retention. The paint business uses approximately 600 million pounds of plastics annually as solid bases for protective coatings.

The multitude of products stemming from chlorobenzene includes some of the spectacular products which the war brought forth. DDT has perhaps been the most widely publicized and is only indicative of many others with great peace-time potentialities.

Five years ago, the annual production of 500 tons of styrene was used mostly for electric insulation. At 55 cents a pound, it was too expensive for most uses. Today, styrene capacity is 200,000 tons, a third of the weight of the synthetic rubber the country made for war in 1944. Now, at 18 cents per pound, styrene will have a better chance to compete with established materials.

It cannot be assumed that postwar demands will immediately take up the capacity of the huge war plants, but certainly there will continue to be a large demand for styrene-butadiene synthetic rubber, and surplus styrene will seek new fields. Styrene's candidacy for a spectacular postwar role rests on the chemical's adaptability to many diverse uses and its readiness to combine with other chemicals. Other advantages are its lightness, good insulating qualities, resistance to acids and alkalis, and the clarity and wide range of colors in which it can be prepared.

The makers of styrene have had neither the chance nor the manpower to explore all styrene's possibilities, or to investigate the vast number of compounds. Its versatility is shown in the various physical forms in which it can be useful. As blocks of foam lighter than cork, for instance, it insulates the walls of airplanes or gives buoyancy to life rafts.

Whether or not styrene promises a postwar chemical revolution, as has been predicted, remains to be seen but its possibilities are intriguing and seem endless.

Our scientists have gone far in developing new materials and new uses for old materials, and in doing so, they have called upon the coking industry for help in taking coal apart so that it might be put together again in new forms. The industry has responded with improved recovery practices, finer distillation, and products of greater purity, while it continued its primary function of providing coke to the iron and steel industry. Truly, the modern coke oven is as essential to the chemical industry as it is to the iron and steel industry, which it continues to serve.

DISCUSSION

PRESENTED BY

H. S. OWENS, Assistant General Manager, Donner-Hanna Coke Corporation, Buffalo, New York

P. S. SAVAGE, Vice President, Donner-Hanna Coke Corporation, Buffalo, New York

DANIEL K. SEGUR, Research Chemist, Donner-Hanna Coke Corporation, Buffalo, New York

H. S. Owens: The by-product ovens, which had their start shortly before the turn of the century, improved on the old beehive ovens by eliminating the waste of gas products. With the recovery of these products, in addition to coke, it was then economically possible to locate the by-product type of oven at the steel plant site instead of at the coal mine.

Mr. Pugh gave an approximate yearly coal requirement figure for the several plants of the Niagara frontier. This figure reduces to about ten trainloads of coal, twenty cars in length, daily. The movement and handling of this coal is a major task during the heavy winter months.

The importance of gas production at the coke ovens cannot be overemphasized. Local gas needs are usually at their peak when the weather conditions are extremely bad. It can therefore be stated that the uninterrupted operation of coke ovens during cold weather is vital to the comfort of the Buffalo community.

The end uses of products other than coke obtained from modern coke oven operation have been ably

presented by Mr. O'Neil. In the past, the value of these products, in addition to the value of the coke, permitted the heavy investment which was required for the building of modern coke plants. Today, prices received for these products in many locations do not justify modernization expenditures.

There has been considerably development of the ammonium sulphate recovery process within recent years, and the same is true of the refinement of benzol products. The original equipment of these processes is now obsolete, and must be replaced with apparatus of advanced design to compete in the present day markets.

P. S. Savage: I would like to take this opportunity to point out the fact that while the by-product coke oven is the basis of a great chemical industry, it has not been treated with very great consideration during the war period. While the coking industry has been asked to make better products and place them where most needed to help the war effort, the prices of these products have been held down by the O.P.A. to those prices existing in 1940 and 1941, and in many instances are lower than the depression prices of 1933-34. At the same time, O.P.A. has allowed the price of coal, which constitutes by far the largest cost to the coking industry, to double its 1941 price, which in turn was double the price in the depression years of 1933-34. Labor costs, due to premium overtime and wage increases, have also practically doubled since 1941.

As a result of this policy, commercial coke plants are no longer economical. There are at least three commercial plants contemplating shutting down completely, and at least one large plant is contemplating burning all their gas in boilers, with the by-products left in the gas, since they cannot afford to extract them from the gas. Unless there is more realistic pricing of the chemical products of coal, there may be an insufficient supply of these vital products produced to form the basis for the modern chemical industry Mr. O'Neil has pictured.

Daniel K. Segur: Mr. O'Neil has very properly outlined the uses to which coke oven products are put by chemical industry. A few words emphasizing the dependency of the chemical industry on one, benzol, may be justified at this time.

Firstly, benzol in a technically pure condition has not yet been produced from petroleum in a quantity interesting to the peacetime customer. A limited portion of California and Texas crudes contain a fraction which is reasonably rich in compounds which can be transposed into toluene and the xylenes by suitable treatment usually classified as "cracking." The toluene thus produced during the war has been of good quality and in sufficient quantity to fill an essential war need. While the xylenes are not yet available from this source in a pure condition, they may be on the way. However, work to date has indicated that petroleum benzol is a rather remote target.

Mr. O'Neil has mentioned certain commercial products which use benzol as a starting point and in large quantity. Of these, styrene and GR-S, phenol and the phenolic plastics, the nylons, DDT, colors and medicinals, will create a benzol demand about equal to the total production, if not in excess of it.

Styrene as a plastic has been a heavy consumer of benzol, for it cannot be competitively synthesized from any other start, and it will continue to be in heavy demand because of exceptional properties as a plastic. Styrene existing as such in light oil is a possible source but too small in quantity to be of consequence.

Styrene as a component of GR-S type synthetic rubber will certainly be in heavy demand although present estimates are guesswork. The other half of GR-S, butadiene, can be made from benzol, and may be so made in the future, but it is now being made from either alcohol or petroleum, and is therefore not judged to be a benzol product at present.

Considerable phenol is recovered from tar distillates but the quantity is about equaled by the demand for products other than plastics. The phenol-formaldehyde plastic industry which is large and growing, is therefore dependent upon synthetic phenol which, in turn, is produced from benzol only.

We all agree that nylon production will increase at a rapid pace and that benzol gallonage required for this product will grow with the expansion of nylon.

DDT is the youngster of this group and its growth is problematical, It's growth will eat into benzol supplies, for benzol is the only logical nucleus usable in the present process.

The color industry is too well known to need special note. A heavy part of commercial colors are based on benzol by way of aniline, phenol, etc.

From the viewpoint of the research laboratory, it appears that the time is rapidly approaching when a chemical manufacturer in the field will have a distinct advantage if he has an assured source of quality benzol.

Humidity MEASUREMENT AND CONTROL IN *Steel and Allied Industries*

. . . . whether the blast should be wet or dry is a question on which one may long argue; but there is no question that the moisture should be closely controlled . . . . this discussion describes various methods of measuring and controlling humidity . . . .

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▲ IN recent years increasing interest has been shown by engineers in the measurement and control of the water vapor which enters into iron and steel making processes. The development of newer and modern air conditioning equipment, as well as demands for increased and more uniform production, more rigid control specifications, and the desire to reduce production costs, have encouraged the improvement of old applications and the development of new methods.

The development on many applications, however, has lagged considerably for the want of suitable humidity measuring devices. As compared with other measuring instruments, available humidity instruments have been either difficult to operate or limited in application.

In many instances it would be desirable to automatically and directly record or control dew point, relative or percentage humidity, or absolute humidity. While special instruments have been developed to measure directly such values as dew point or relative humidity, they have not been adaptable to many applications in the steel industry. A main reason is that the operating conditions encountered are probably more difficult than in other industries. When used in steel and allied industries such instruments are often required to operate in dusty atmospheres which may contain complex mixtures of gases; on other applications they must operate in closed pipe systems under wide variations of operating pressures and dry bulb temperature. The space containing the air-vapor mixture may be a closed vessel from which a flow sample to operate a wet and dry bulb cannot be taken. Although moisture addition from the wet bulb is generally negligible, in this last case continual recirculation of the air would eventually result in some build up of humidity.

Although many varieties of humidity control devices have been perfected for use in general air conditioning, and in the food and textile industries, very few of these methods have been applicable to the metal industries. In some applications such as in the control of high temperature drying ovens, humidity must be controlled by indirect means without actual measurement of the moisture, such as by control of the air temperature to give the proper vapor capacity or "drying power" and by proper recirculation or removal of moisture laden air so as to maintain a safe rate of drying.

In certain processes using absorption methods, the addition or removal of moisture from the controlled air is indirectly regulated by automatically controlling, for example, the specific gravity of a hygroscopic solution and the temperature of the air to the contacting tower.

Presented before the Detroit Session of the AISE Annual Meeting, September 24, 1945.

A knowledge of the relations between gravity air temperature and vapor pressure is therefore required to achieve accurate control.

The purpose of this paper will be to review the effects of moisture on several processes, to discuss the various control methods used, and to describe several new and more direct methods of measurement and control of humidity values.

From an instrumentation viewpoint the measurement of such process conditions as temperature, pressure, flow, or liquid level are relatively simple and straightforward. Direct humidity measurement, however, is difficult because humidity is a function of a number of thermodynamic properties of which only temperature is directly measurable. These properties are dew point, temperature, wet and dry bulb temperatures, relative or percentage humidity, specific enthalpy, vapor pressure, and absolute humidity. Knowledge of any two properties will permit determination of all the other properties; and to facilitate this determination these properties have been plotted on psychrometric charts and tables.

Since temperature is the only one of the above properties that is directly measurable, the most accurate industrial humidity instruments employ some form of temperature measurement to determine energy changes in air-vapor mixtures. Rational psychrometric theory have made it possible to determine the relation between wet and dry bulb temperatures and other humidity properties. With this knowledge the calibration of humidity is made possible.

In addition to instruments using temperature measurement, other humidity measuring methods have been utilized which are based on indirect physical, electrical, or chemical principles. These include:

1. Elements made of hygroscopic materials.
2. Electrical methods, which may be further classified as:
   a. Thermal conductivity.
   b. Special circuit arrangements to give direct reading humidity values.
   c. Specific inductive capacity.
   d. Ionization.
3. Absorption and other chemical methods. Of these indirect methods only the hygroscopic type is used to any great extent in the metal industries and then only in limited applications where clean atmospheres prevail.

Figure 1 shows a direct reading relative humidity recorder which uses a wood parchment element having good stability and sensitivity characteristics; changes in atmospheric humidity cause dimensional changes in the element which in turn moves the pen. In addition to the humidity pen, a dry bulb pen is also available in this recorder. Where there is not enough natural circulation to bring a representative sample in contact with the measuring element, the recorder is equipped with a fan which blows air across the element and thus insures adequate sampling. A source of power is required to operate the fan motor. This instrument has found wide use in the metal industries for test work.

The applications covered by this discussion will be based on psychrometric or other forms of temperature methods. Humidity control as practiced in the metalworking industries may be classified according to the type of measurement made or more broadly according to application as follows:

Type of measurement —

1. Dew point temperature.
2. Relative or percentage humidity.
3. Measurement of temperature differential or heat head.
4. Absolute humidity.

Classification according to general applications —

1. Air conditioning of spaces.
2. Quantitative control of moisture content.
3. Drying, enameling, varnishing, and baking processes.
4. Engineering or laboratory test determinations.

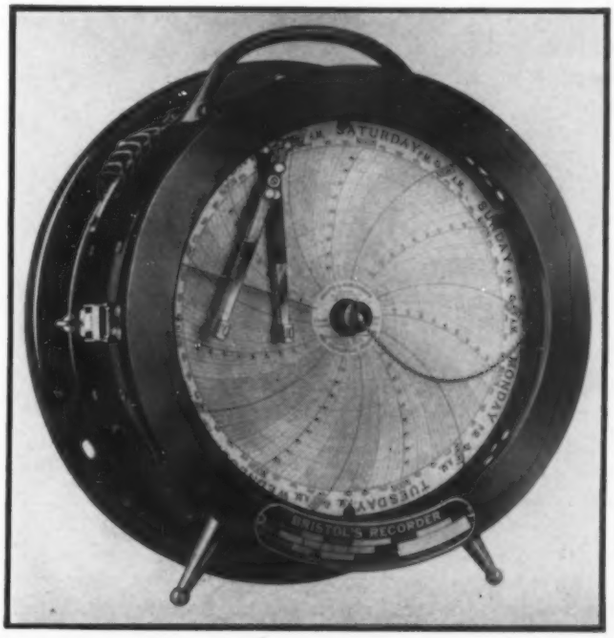
Only the first three classifications will be covered in this paper. The various types of measurement will be discussed under the applications in which they are used.

GENERAL AIR CONDITIONING

Complete air conditioning of a definite space has been defined as the creation and maintenance of an atmosphere having such conditions of temperature, humidity, purity, and air circulation as to produce desired effects upon the occupants or upon the materials that are stored there. Except for an occasional installation in office buildings, air conditioning control in the metal industries is not directed to produce human comfort but to control one or more of the other conditions, usually temperature and humidity, so as to permit the best possible yield during manufacture and for preservation of products in storage. Two applications of particular interest are the air conditioning of motor rooms and warehouses.

Humidity control of motor rooms — Modern motor or generator rooms in steel plants are equipped with air cleaning devices to remove dust from the air. The dust

Figure 1 — This direct reading relative humidity recorder uses a wood parchment element whose dimensional changes move the pen.



to be cleaned is passed through an air filter or washer system of which there are several types. On some of these installations, particularly where large motor generator sets of the welding type are used, it is desirable to also control the relative humidity of the air. Some of these large special generators are equipped with a great many brushes, whose wear is affected by the humidity of the air. For example, if the air is too dry the brush surfaces in contact with the commutator bars wear down rapidly by powdering; on the other hand, too high a humidity makes the brushes pasty which also shortens their useful life. Some of these brushes have been known to wear down within a few hours.

In order to correct this difficulty, air conditioning equipment using fans, water sprays, and suitable heating and tempering coils is used to automatically control the relative humidity of the air in the room. Control may be either manual or automatic. A direct reading hygroscopic recorder is usually used when control is manual; when control is automatic, standard wet and dry bulb instruments are used to control the air temperature and humidity.

Preservation of finished steel products — Every year the steel industry loses large sums of money from corrosion caused by improper storage and shipment of finished products, especially where steel surfaces carry very thin protective oxides or are polished. While large heavy sections or roughly finished products which carry a heavy oxide protection resulting from the process may be further protected by oiling, painting, or greasing; it is necessary to better protect the lighter products which have finished surfaces. Sometimes, as in the case of strip and cold rolled steel, oiling and wrapping in paper or cloth is sufficient. When such products as black, coated, or bright annealed sheets, nails or wire products, and plate must be stored without wrapping, some form of air conditioning must be used to insure maximum surface protection.

To reduce reconditioning costs of rusted products and scrap losses due to corrosion, storage warehouses are built with insulated roofs, tight doors, and heating systems with forced circulation that will insure the maintenance of the proper heat head of the circulated air with respect to the steel temperatures. In addition some warehouses are equipped with a more completely air conditioned room in which to store more particular products.

The instrumentation requirements are simple. All that is required is a dry bulb temperature controller and an instrument to measure relative humidity. The relative humidity instrument is usually a wet and dry bulb thermometer, although a direct reading hygrometer is sometimes used.

On the wet and dry bulb installations which are of the distance type, the dry bulb is usually placed in a dummy pile of stored steel. The temperature difference between the dry bulb temperature and the wet bulb reading is set as required to maintain the proper humidity and dry bulb temperature.

The temperature controls are usually automatic, and in larger warehouses may require a number of instrument installations, with individual control near each zone of the unit heaters. As the methods are similar to those used in general air conditioning, details will not be given here.

RUSTING OF STEEL PRODUCTS IN SHIPMENT

Even though great care in corrosion prevention be exercised at the warehouse, damage due to rusting may result in shipment to the final location. This is particularly true when river shipment by barge is made from northern climates to the more humid southern regions.

Where the product is properly inspected, banded, and wrapped, or oiled before shipment, little trouble has been experienced from corrosion. In most cases where damage occurs it can be traced to torn wrappings, improper use of wrapping glue, use of wooden blocks and skids, and careless loading into the boat.

When the product is not wrapped, however, much damage due to high humidity can result. At certain times of the year, for example, the steel is loaded into barges at a relatively low temperature and the shipment starts southward. Because of the large mass of steel, the barge may reach the more humid southern climates before the steel has become warm. Under such conditions it is possible for some of the steel to be at a temperature below the dew point corresponding to the moisture in the air. This condition results in a condensation of moisture on the product surface which causes damage. Even if the steel does warm up sudden increases in humidity may cause condensation.

Several attempts have been made to overcome this difficulty. One steel company used covered barges in which were placed oil stoves to gradually heat the air in contact with the steel. A two pen thermometer recorder measured the air temperatures inside and outside the barge. By heating the inside air to a temperature always higher by at least 10 F than the outside air no condensation of moisture resulted. The heater capacity was sufficient to raise the steel temperature at a safe rate in case of sudden temperature drops. The disadvantages of this method are the inconvenience of fuel handling, the cost of fuel, and the constant attention which is required.

It is finally planned to construct a special tightly closed barge using a false bottom with suitable openings to insure proper circulation of heated or dried air through the mass of finished products. The barge was to be equipped with suitable drying equipment and circulating fans, all to be automatically controlled. However, the start of World War II interrupted these plans and the barge was never built.

Another scheme which has been tried is the use of chemical drying agents, but this method has not been successful.

QUANTITATIVE CONTROL OF MOISTURE CONTENT

While some humidity controls are used to maintain relative humidity, either for comfort conditions or to regulate "drying power" there are some industrial applications where a quantitative measurement in terms of absolute moisture content is desired.

To make a direct measurement of absolute humidity in unsaturated air-vapor mixtures by psychrometric methods is not simple, but by certain combinations of

instruments it is now possible to give a direct, continuous reading in grains of moisture per unit weight or standard volume of dry air.

The first difficulty which arises in attempting a direct measurement by wet and dry bulb methods is that pressure conditions within the air-vapor space may change; this change alters the relation between the wet and dry bulb readings, or their differences, and the corresponding values of both saturation and actual values of absolute humidity. That is to say, any psychrometric chart which shows the relations between the wet and dry bulb and other humidity conditions represents a constant pressure process and is accurate only at the pressure condition for which it was plotted. Increasing or lowering the total pressure in an air-vapor space, for example, increases or lowers the dew point. Another way to state this, is to say that the saturation humidity corresponding to a particular temperature varies approximately inversely as the absolute pressure of the mixture.

While the percentage of error is not great under normal changes of atmospheric barometer, it is quite large when the pressure reaches several pounds and must be compensated for if accuracy is desired.

Another difficulty that is encountered in making a direct measurement of absolute humidity is that the relation between values of wet and dry bulb, or their differences, and the corresponding humidity are not simple. However, this can be taken care of from an instrumentation standpoint by several methods.

If the air-vapor space of which the humidity measurement must be determined is in a saturated condition, as is the case when saturating the mixture with a spray, knowledge of the dry bulb temperature alone will give an indication of the moisture content since the dew point, wet bulb, and dry bulb temperatures are equal at saturation. Here again, however, if there is much pressure variation in the vapor space, as in the case of post-compression spray type dry-blast systems, correction for pressure changes must be made.

In order to illustrate this type of measurement the instrumentation on several types of dry and wet blast systems will be discussed.

Methods of automatically recording dew point or absolute humidity under variable pressure conditions on the pressure side of the blower will be covered.

ABSOLUTE HUMIDITY CONTROL OF AIR TO BLAST FURNACES AND CUPOLAS

It is generally agreed by blast furnace and cupola operators that uniform moisture control of blast air to the furnace is desirable. All operators attempt in some way, usually by manual adjustments to compensate for normal daily variations in atmospheric humidity. However, for the past several years, quite a controversy has raged as to the proper level of moisture to be maintained, particularly by blast furnace men. On the one hand, a number of dry blast systems have been installed, some of which are capable of reducing blast moisture content to as low as one grain per cu ft. At the other extreme, some operators are injecting moisture to maintain levels of 15 to 20 grains.

Both schools seem to agree that uniformity is desirable; the following advantages are claimed for both methods:

1. Better furnace regularity, with less sticking, hanging or slipping, making it possible to operate at higher hot blast temperatures, and less shifting of the zones of fusion in the furnaces.
2. Less flue dust produced because of better working of the furnace.
3. More uniform iron analysis is obtained, particularly in regard to silicon content.

While both schools agree that uniformity is desired, dry blast advocates contend that high moisture addition is detrimental to efficient operation, both from thermal and economic view points. The principal objection is the extra cost of coke to compensate for the moisture additions. The main justification for recent dry blast or low moisture installations has been increased production and decreased coke rate.

Although some of these installations have resulted in increased production others have not been able to report greater tonnage output. These inconsistencies in results have been the cause of much discussion; some claim that dry blast can show better and more economic operation only when used on inefficient furnace systems, as when stove heat capacity is insufficient; or on furnaces making high silicon iron or ferro-manganese. Others claim that many of the benefits shown by the early dry blast systems are now difficult to achieve because of improved furnace designs and practices such as better selection and sizing of raw materials.

Operators using moisture addition report that although coke consumption per ton of iron is slightly higher, the increase in iron production, more uniform silicon content, and smoother furnace operation more than offset the extra cost for coke. It is claimed that moisture addition is economical only when ample stove heat is available as otherwise the coke requirements will be higher and no tonnage increase will be noticed.

To illustrate the differences of opinion which exist, it is of interest to note the conflicting observations made in two recent papers.

One operator, in reporting the results of tests made on moisture addition concludes that on the basis of their tests, controlled moisture addition to the blast cannot be justified from an economical standpoint. He further concludes that the most economical way to blow a furnace is to dry the air to a level of ½ to 1 grain per cu ft.

The other operator, in reporting on actual operation of a post-compression type of dry-blast system, observes that by stabilizing the moisture at a low level of approximately 1½ grains per cu ft nothing was achieved. After attempting various methods of compensation by increasing the burden and adjusting the blast column, it was concluded that for this furnace dry blast promotes kicking.

Several other operators with dry blast systems capable of drying to 1 or 1½ grains have had similar experiences and have finally stabilized their operations at levels of 3 to 4 grains with better results. It appears that there may be a point of optimum moisture content for a given furnace, below which the reactions slow down and below which it is not desirable to dry the air.

Whether it be dry-blast or uniform wet-blast control, accurate measurement is a pre-requisite to good control.

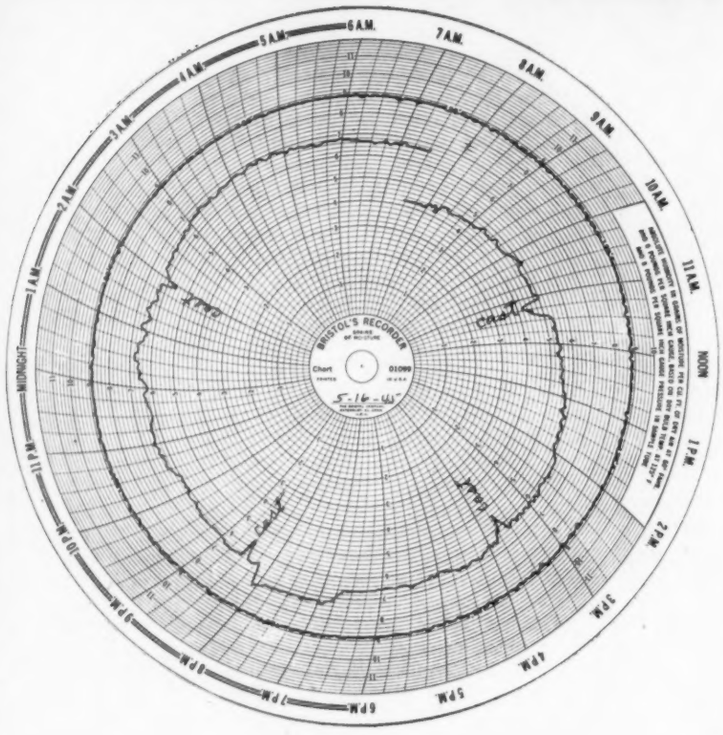
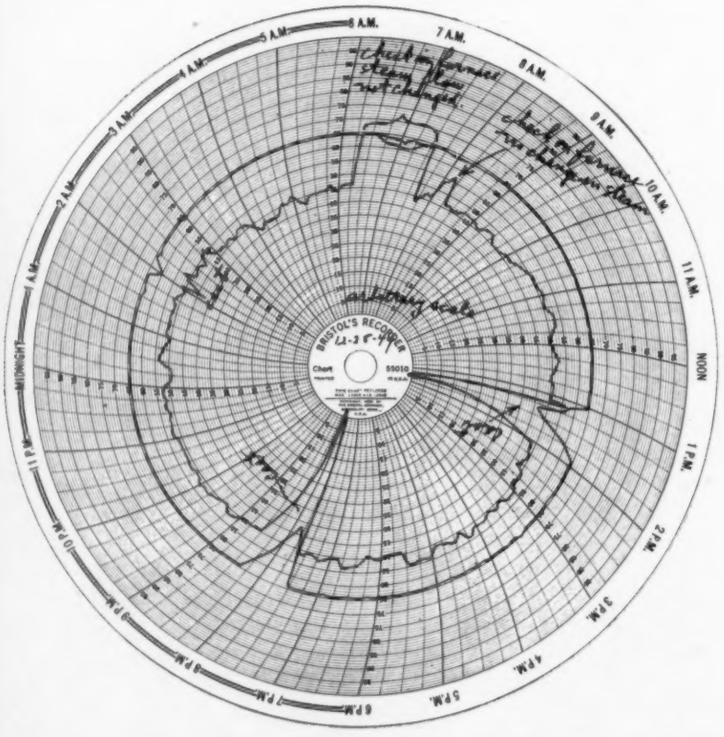


Figure 2 — The chart shows a record of the natural moisture when there is no control on the blast. Note drop at 8:05 p.m.

▲

Figure 3 — This chart shows the humidity record, when humidity is controlled by adding steam to the blast manually. Note variation in humidity due to difficulty in following variations manually.



The measurement is simplest in pre-compression dry blast systems where a dew-point measurement of saturated air is possible. Because of the unavailability of instruments for wet-blast control, only a few are able to control from an absolute measurement after steam is injected. Many installations attempt to control indirectly by setting steam flow and air flow rates after taking a wet and dry bulb reading at the blower intake.

This system of measurement has many disadvantages, some of which may account for the difference in results obtained from tests on moisture addition. First it requires the services of an attendant and is, therefore, subject to personal errors in reading and interpreting wet and dry bulb readings; which is especially true in bad or foggy weather when there is little or no difference between wet and dry bulb readings.

The inherent limit of accuracy of the air flowmeters, especially where reciprocating blowers are used, is also a determining factor in the overall accuracy obtainable. On manual control where correction must be made hourly, it is sometimes difficult to follow fast humidity changes. The chart in Figure 2, on which is recorded the natural moisture variations in one day, illustrates the changes manual control would have to follow. On the day recorded by the chart of Figure 2, the temperature rise from morning till dark was from 59 to 89 F at the air intake. With the humidity rising continually at 8:05 PM, a violent storm broke which dropped the air intake temperature 10 F in a few minutes. The absolute humidity also dropped sharply about 1 grain. It can be appreciated that manual control cannot do a good job under such conditions. Figure 3 which shows the controlled humidity record after the steam is added to the blast by manual means, illustrates the point very well. Comparison of Figures 3 and 2 shows that the manually-controlled record has greater variations than the natural moisture record. Actually natural humidity does not normally change as fast as the controlled humidity varies in Figure 3.

DEW POINT OR ABSOLUTE HUMIDITY INSTRUMENTS FOR AIR BLAST SYSTEMS

Three methods of humidity measurement are used on air blast systems. Control on pre-compression types of spray systems is very simple and a standard dry bulb recorder controller is used; the sensitive bulb is placed at a location where the air is saturated. In chemical systems where the dehumidified air leaves the dryer at superheated conditions, it is best to measure the humidity after the blower with the same type of instrument as is used on wet blast applications.

In post-compression systems where the air is saturated by a spray, it is possible to measure the humidity with a special form of thermometer controller.

HUMIDITY MEASUREMENT OF SATURATED AIR UNDER VARIABLE PRESSURES

Figure 4 shows the general layout for a blast furnace dry blast system of the post-compression type. This system saturates the blast air with water vapor after

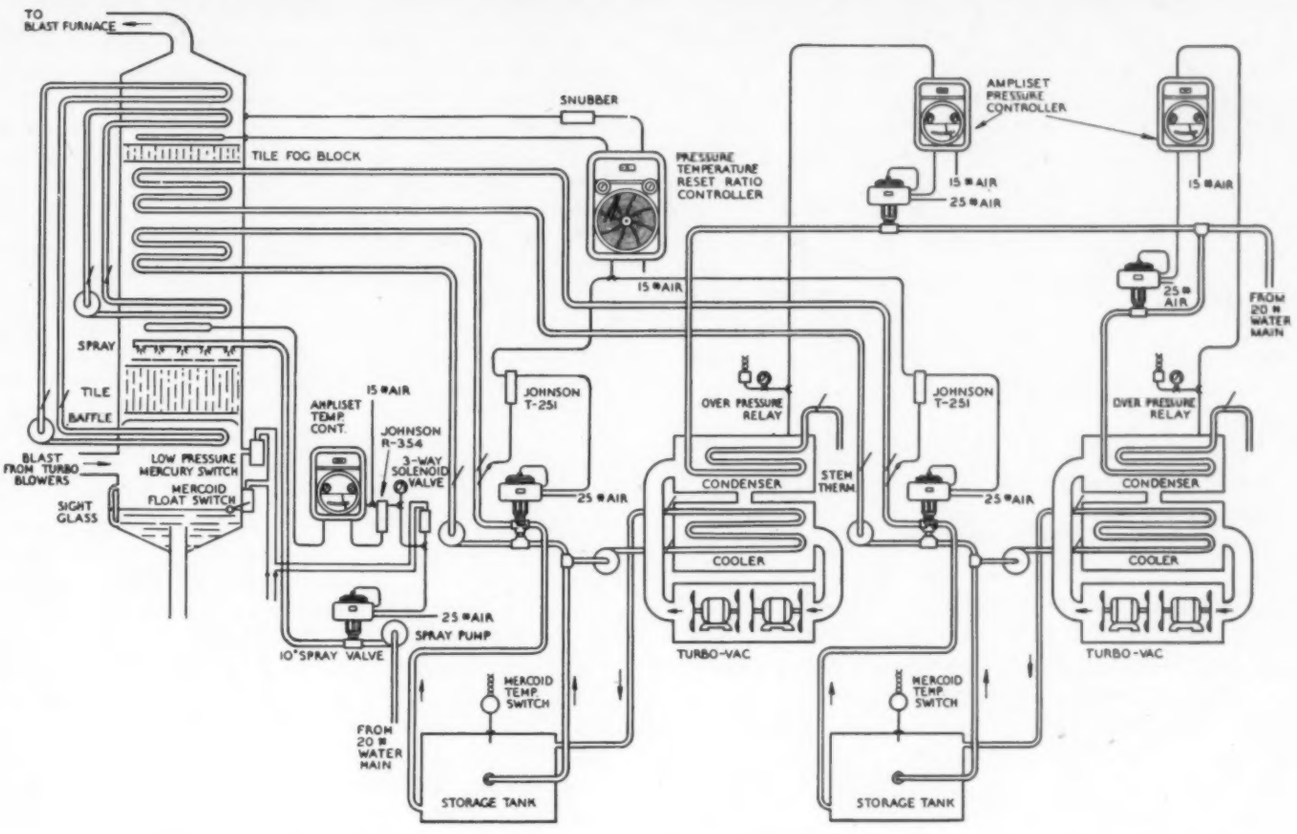


Figure 4 — Drawing illustrates general layout of a post-compression type dry blast system.

the blower and refrigerates it to as low as 36 F at normal blowing pressures.

The refrigeration equipment consists of two separate turbo-vac units with a total capacity of 270 tons of refrigeration for approximately 50,000 cubic feet per minute of air required for the furnace.

Cold anti-freeze solution is passed through two cooling coils in the tower. There are two paths of circulation with separate pumps for each turbo-vac. This double system allows the refrigerating unit to operate in long time cycles, thus making more efficient operation possible.

As the air enters the cooling tower it passes through a cooling water spray. Plant water is used and the temperature of the air is reduced to saturated condition a few degrees above the temperature of the water. A throttling type air operated thermometer controller regulates the air temperature at this point.

The dew point or, effectively, the absolute humidity of the air is measured by a simple thermometer bulb immediately after the saturated air passes the cooling coils and tile fog blocks. In order to compensate for pressure variations a pressure measurement must be made at this point; both temperature and pressure readings are transmitted by connecting tubing to a pressure-compensated temperature recorder-controller. This instrument, which is an air operated reset throttling controller, modulates cooling refrigerant valves on the cooling coils in the tower. The latest control arrangement is such that during very cold weather, when it is possible to control moisture content by spray water alone, this controller is switched over to operate the water spray valve and the cooling valves are cut out of operation. The diagram does not show this piping arrangement.

ABSOLUTE HUMIDITY MEASUREMENT OF UNSATURATED AIR UNDER VARIABLE PRESSURE CONDITIONS

When the vapor space is not saturated direct measurement of absolute humidity is more difficult.

Figure 5 shows a moisture control layout that is being used on blast furnace cold blast mains to make steam additions after the blower. The absolute humidity is directly recorded on a chart in grains per standard cu ft of dry air; the measurement is made on the high pressure side of the blower after steam is injected into the main. This method of measurement is independent of any air flow changes or errors in steam flow measurement, as is the case in manual control methods where the humidity is measured only ahead of the blower and not after steam is added.

The recorder operates on the following principle: A continuous sample of blast air is piped from the cold blast main to the packaged unit control panel shown in Figure 6 on which is mounted the equipment shown in the diagram. The air enters the sampling line under variable temperatures which depend upon the heat of

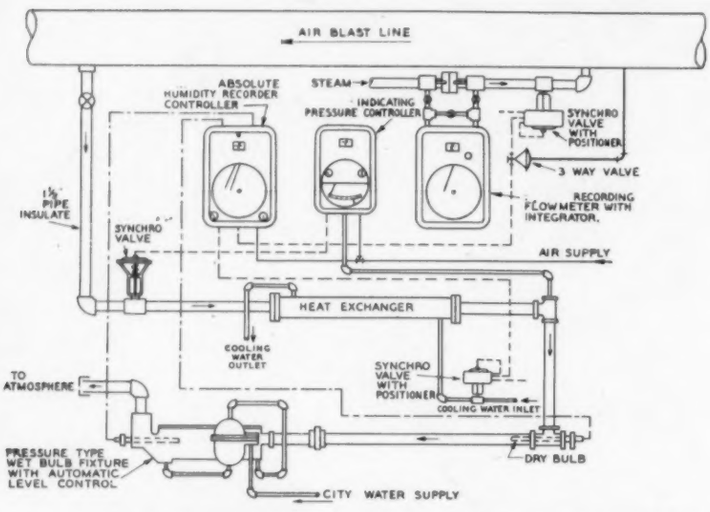


Figure 5 — Moisture control layout on cold blast main of blast furnace used to add steam after blower.

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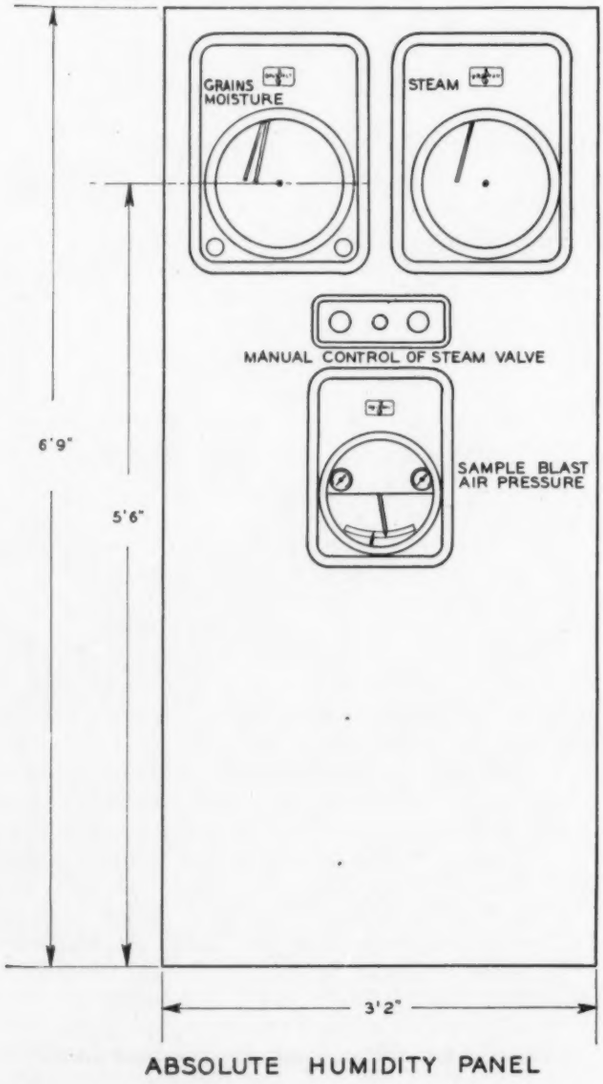
Figure 6 — Packaged unit control panel which is used to control humidity for layout of Figure 5.



compression, and under variable pressures which may be as high as 30 lb on some furnaces.

The first requirement is that correction be made for pressure, since, as was stated before, any psychrometric chart represents a constant pressure process. To accomplish this correction, the sampled air pressure is reduced to a constant pre-determined low pressure, below normal blowing pressure by an air-operated diaphragm control valve which is operated from an indicating pressure controller. This controller measures the pressure at the wet and dry bulb fixture and keeps it constant.

The absolute humidity is also a function of the dry bulb and wet bulb temperatures or their difference. By measuring any two of these functions and keeping one constant by use of a controller, it is possible to directly record the absolute humidity. The diagram in Figure 5 shows a two pen recording thermometer with wet and dry bulbs, which show directly the absolute humidity, each pen operating an air control mechanism. If the dry bulb is kept constant, for example, variations in humidity will change the wet bulb reading, so that this reading will be an indication of the absolute humidity in the main.

Figure 7 shows this change of state on a skeleton psychrometric chart. From the law of mass conservation, it can be assumed that the weight of water vapor per pound of dry air ahead of the pressure reducing valve is the same as after the valve. The state of the mixture immediately after the valve can be represented by point A on a phychrometric chart showing humidity and dry bulb as ordinate and abscissa respectively, and lines of constant wet bulb on the slope. The dry bulb pen, through a small heat exchanger and control valve cools the sample, along a constant humidity line, from state A to state B, at which the corresponding wet and dry bulb coordinates are at lower temperatures than at A. It can be seen that by assuming a number of A states at various humidity levels and wet and dry bulb values, and cooling at constant humidity to various B states on a constant dry bulb line, the relation between wet bulb readings and humidity can be obtained.

Figure 8 shows the relation between wet bulb and absolute humidity. The wet bulb fixture, which is pressure tight, uses a wick with constant water level float arrangement.

We have mentioned several advantages in measuring the humidity on the pressure side of the blower in regard to direct as against indirect methods. In addition to these, there is one further advantage that should be mentioned. When a wet and dry bulb reading is attempted under normal temperatures and lower humidities ahead of the blower, the temperature difference may be very small. By measuring the humidity of this same sample on the pressure side of the blower, advantage is taken, because of the heat of compression to obtain wet and dry bulb readings at a temperature of 125 F. The advantage of this method is that the temperature difference is amplified, in some cases as much as 10 times or more. Under these conditions, where a fraction of a degree error in reading ahead of the blower will affect accuracy considerably, the same error would have much less effect on accuracy at the higher temperature. Even though the intake air be

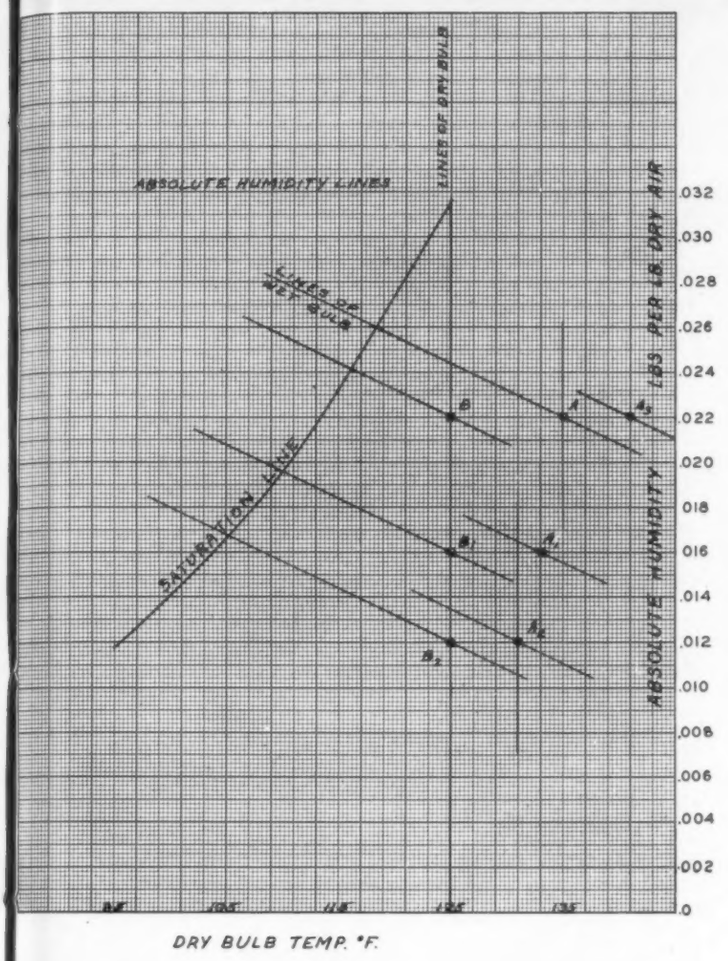


Figure 7 — Skeleton psychrometric chart illustrates thermodynamic changes of state undergone by air-vapor sample in humidity measuring instrument.

entrained with air or fog, measurement on the pressure side will always be correct.

A steam flowmeter is used to record and integrate the amount of steam added.

The controller just described may also be used on dry blast applications as shown in Figure 6.

Figure 9 shows a record made on a chemical type dry blast system where moisture may be added or taken out of the air. On this application instead of directly adding steam to the blast, the instrument controls the gravity or concentration of the absorbent which in turn determines the absorption properties of the contact surfaces. In Figure 10 is plotted the natural moisture variations and the controlled humidity for two weeks in July.

Figure 11 shows a record made on a wet blast application where moisture can be added only. The chart shows an overlapping record for about 40 hours.

The dips on Figures 9 and 11 are caused by a shut-off valve which operates during cast periods or at any time the blast pressure falls below 8 psi, below which it is not desired to add moisture. On all these charts there is a record of constant dry bulb and the wet bulb or absolute humidity record.

HUMIDITY CONTROL FOR CUPOLAS

As with the blast furnace operators, foundry men have also agreed that regulation of the moisture in the blast is advantageous. However, because most cupolas do not preheat the blast, it is preferred to dry the air to a constant low humidity value. A number of air conditioning installations have been applied to cupolas.

Another argument that is used in favor of dry blast is the effect of hydrogen on the physical characteristics of the product, particularly if it is malleable iron. A number of investigators have claimed that moisture adds hydrogen to the metal, and that hydrogen in small quantities, in the order of 0.0005 per cent by weight has an injurious effect upon both iron and steel. The following defects have been attributed to this cause:

1. Prolongs annealing time of malleable iron.
2. Retards graphitization.
3. Produces cracked castings and causes flaking in steel.
4. Causes brittleness and otherwise impairs physical properties of metals.

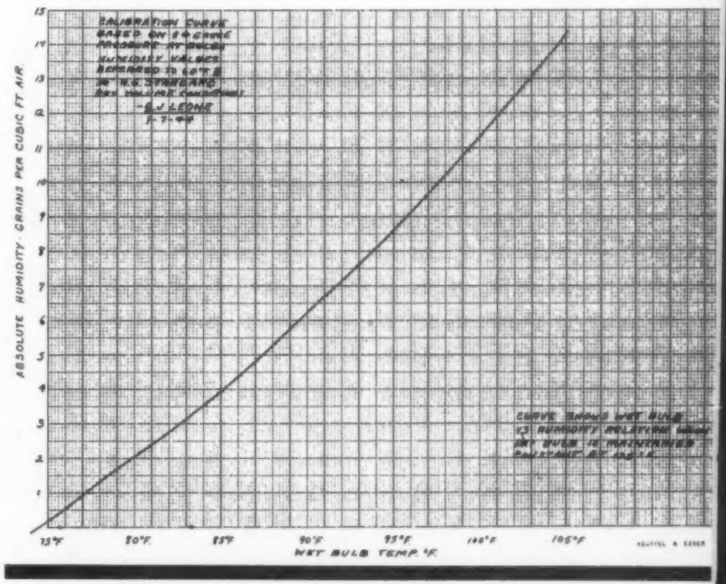
Some operators of malleable plants report that best operation is secured at a moisture level of four grains.

The drying equipment and control methods for cupola applications are similar to those used on blast furnaces except for variations in size, and operating volumes, temperatures, and pressures of the blast.

WATER VAPOR IN CONTROLLED ATMOSPHERES FOR HEAT TREATMENT

A very live subject among metallurgists today is the determination of the amount of water vapor in prepared atmospheres which are used to prevent excessive scaling, carburization and decarburization. Water vapor is

Figure 8 — Calibration chart which gives absolute humidity directly when wet bulb temperature is known. Dry bulb is kept at 125 F.



always present to a considerable extent in most controlled atmospheres and causes decarburization which may soften the surface of the material. When cooling heat treated steel in an atmosphere containing water vapor, surface discoloration may result if the conditions of atmosphere and steel surface are not at chemical equilibrium. Even though the original atmosphere has the moisture entirely removed before introduction into the heating chamber, the presence of CO_2 and H_2 will cause more H_2O to form by the water gas reaction which occurs between hydrogen and carbon dioxide at high temperatures.

It is necessary then to adjust the gas generator to give the best ratios of H_2O/H_2 and CO_2/CO that will cause minimum reaction with the heated steel surface.

A number of manual and automatic instruments are available for measuring the concentration of such gases as CO_2, H_2, O_2, and H_2O.

Determination of the amount of H_2O has been manual and usually by dew point methods, where the air-vapor sample is gradually cooled until moisture condenses on a mirror surface. The temperature at which condensation occurs is termed the dew-point. Having found the dew point the amount of water vapor can be obtained from tables or charts.

On the larger atmosphere generators, attempts have been made to automatically record and control the dew point of the special atmosphere. Several types of automatic dew-point recorders have been developed within recent years, using a mirror with photo-electric condensation detection and a means of detecting and recording the temperature at which dew forms. However, because the mirror must be alternately heated and cooled, a continuous direct reading that is adaptable to continuous control is not possible.

It has been suggested by a number of metallurgists that on some of the larger gas generators of 15000 cu ft per hour capacity or larger, it may be practicable to use a direct reading absolute humidity recorder similar to the one just described. This recorder would be used on atmospheres which do not vary greatly in composition and the dew points of which vary from 0 F to 100 F, since it is doubtful that wet and dry bulb methods would be accurate at dew points below zero. In order to obtain greater sensitivity and to keep the flow sample as small as possible, a two pen resistance thermometer would be used. With this type of equipment the operation of the dehumidifier would be made automatic.

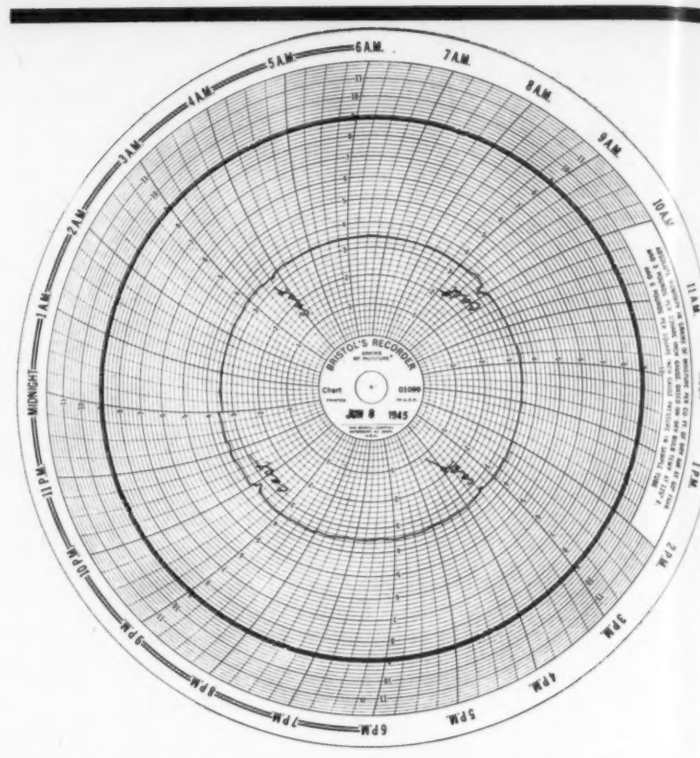
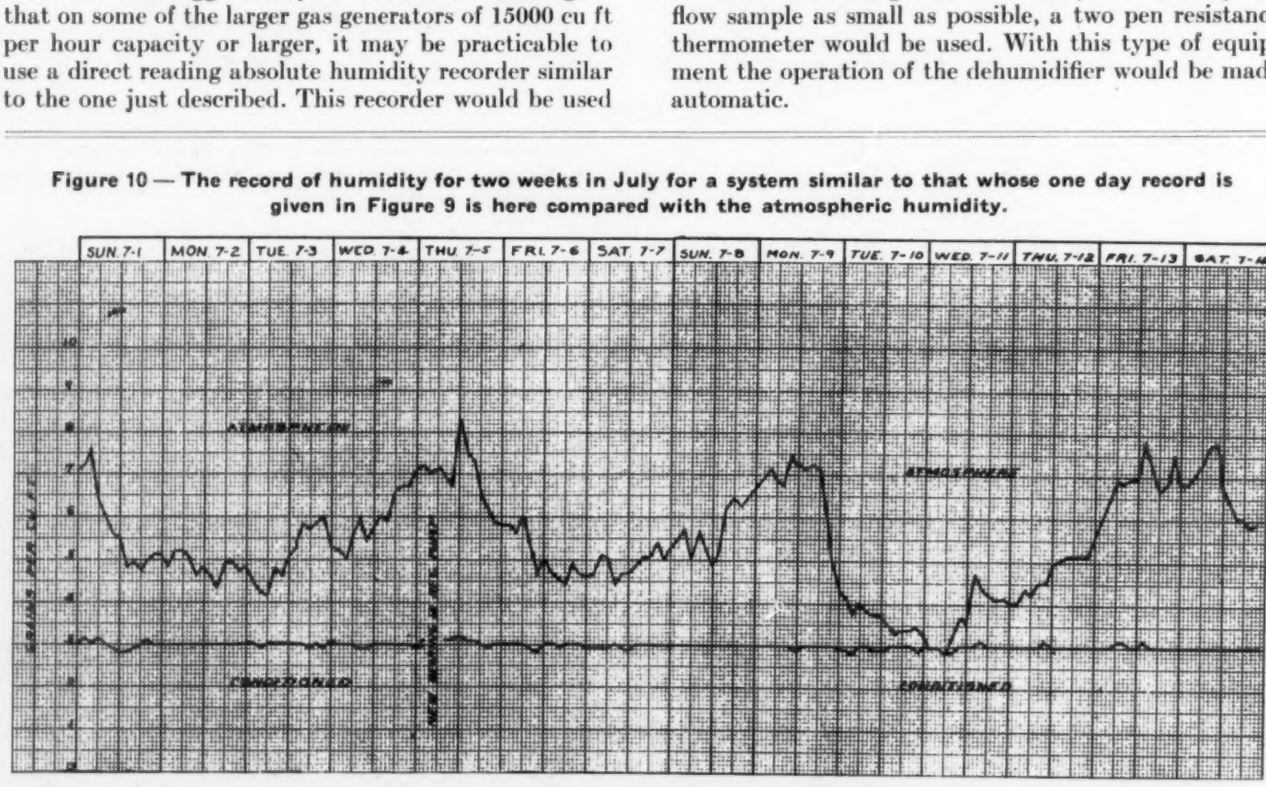


Figure 9 — This chart shows the humidity record of a dry blast system where the humidity has been automatically controlled.

Figure 10 — The record of humidity for two weeks in July for a system similar to that whose one day record is given in Figure 9 is here compared with the atmospheric humidity.



Since the pressures at the point of measurement are very close to atmospheric, pressure correction would be negligible and the chart could be calibrated in terms of dew point. Because of the increasing scale characteristics of such a chart, the dew-point range across the scale must be limited to a maximum of about 30 or 40 F.

While this application has not yet been attempted, an installation is contemplated and will probably be tried soon.

DRYING, ENAMELING, VARNISHING AND BAKING PROCESSES

There are a number of operations in steel and allied industries in which dry heated air is circulated over wet or hygroscopic solids to remove the admixed water so as to dry the material. Because of the large quantities of refractories that are used in metal processing equipment, it should not be out of place to mention the drying control of firebricks, ladle sleeves, stoppers and nozzles, crucibles, retorts, and other shapes. In addition there are certain coating or surface finishing operations, such as, enameling or varnishing in which proper control of drying is necessary to insure a good product.

Much study has been given in recent years to the mechanism of air drying of solids; the influence of such factors as temperature, humidity, air velocity, and the composition and form of the solid material upon the rate of evaporation has been determined. It has also been proven that in such applications as mentioned above, most of the product defects and shop troubles can be traced to the drying operation; it has been shown that good drying is just as important as the firing or burning operations.

Drying action — Fundamentally, drying of plastic solids and enamels consists of energizing the water, by evaporation, from a liquid to a vapor and removing that vapor from the solid surface. The heat supplied by the circulating, dry, heated air serves three purposes: it energizes the liquid film on the wet surface to change its phase to a vapor, it increases the vapor-carrying capacity of the surrounding air, and it increases the flow of the liquid water from the interior to the surface of the solid. This flow of liquid is caused by diffusion or capillary action within the material being dried.

If the surface evaporation is excessively rapid, that surface becomes dry, while the interior is still moist; this sets up a concentration gradient of moisture from the center to the outside which finally results in the formation of a brittle and dry case around the solid. Also, it sets up a differential between the vapor pressure inside the solid and that of the surrounding air which may rupture the brittle case. In enameling operations, too slow a rate of evaporation will cause rusting of the metal; too fast a rate causes shrinkage strains and case hardening which prevents drying of the enamel down to the metal. This may show up in tearing, curling, or popping off of the dry coat.

It is evident from the foregoing that in drying such products, it is essential to avoid setting up too large a moisture concentration gradient between the surface and interior; this calls for controlled heat to expel the vapor, and controlled air movement and humidity to facilitate the removal of water vapor.

Generally, the measurement and control of humidity in refractory drying is not difficult because drying temperatures are not too high so that the wet bulb has a good working range. On varnish coating or baking applications, however, because of the higher temperatures, it is practically impossible in most cases to operate a wet bulb, although it would be desirable in many instances to directly control the humidity.

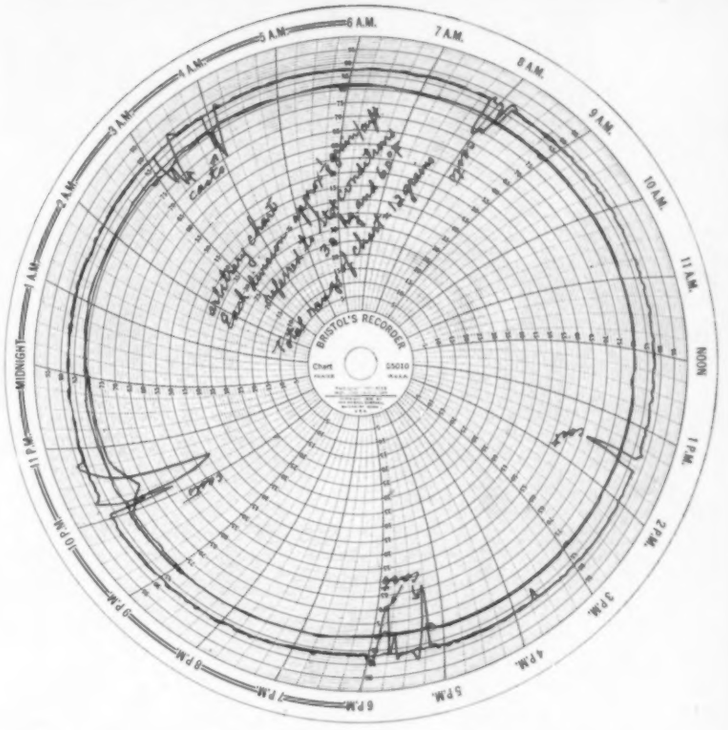


Figure 11 — This daily chart shows record of absolute humidity for the condition where there is automatic control of the wet blast. The record is overlapping and covers a period of 40 hours.

Refractory drying — Two types of driers are generally used, the continuous drier where the refractory passes progressively from one set of temperature and humidity conditions to another, and the batch drier in which the refractory remains stationary and the temperature and humidity conditions change. In the continuous drier, as the air travels over the refractory, which is absorbing heat as it dries, the relative humidity gradually increases toward the cooler end. The furnace length and capacity is designed to control the temperature and drying rates. If the air flow, initial air temperature, or speed of the material change, the desired conditions are not maintained.

By the use of a suitable fan system to introduce dry outside air or humidified air at various places on the tunnel, good control of drying rate can be obtained. A wet and dry bulb controller is used so that the wet bulb controls a steam valve to a jet; the dry bulb regulates the steam supply to heating coils usually placed after the spray. On some installations, the drier is equipped with a fan system to recirculate some of the humid waste air from the drier and to mix the

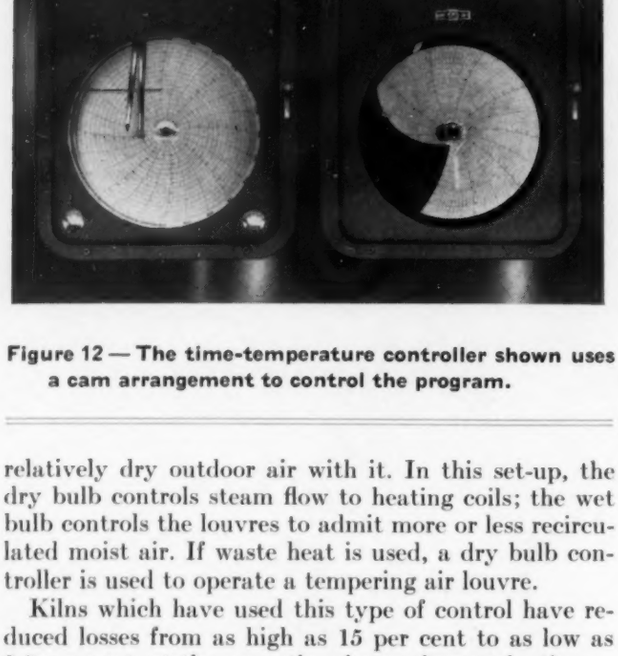


Figure 12 — The time-temperature controller shown uses a cam arrangement to control the program.

relatively dry outdoor air with it. In this set-up, the dry bulb controls steam flow to heating coils; the wet bulb controls the louvres to admit more or less recirculated moist air. If waste heat is used, a dry bulb controller is used to operate a tempering air louvre.

Kilns which have used this type of control have reduced losses from as high as 15 per cent to as low as 0.5 per cent, at the same time increasing production as high as 20 per cent. The addition of control equipment to a continuous drier has the effect of increasing the length 50 per cent, and will do much to correct, at low cost the mistakes on poorly designed kilns.

Batch driers — The advantages of using batch type driers are economy in construction, simplicity in operation and flexibility in varying the drying conditions. At present, batch driers are used for experimental work or if the output is small, or when exact drying conditions are required.

To secure this exact control, particularly if the constant attention of an operator is not available, program or time-temperature controllers are used to control the rate of change of both temperature and humidity.

Figure 12, shows a time-temperature controller using a cam arrangement to control the program. The cam is made from a thin aluminum alloy disc which can easily be cut with a pair of scissors. By installing time-temperature control and recirculation fans on batch controllers, drying time on such products as sleeves and nozzles has been reduced from 144 hours to 72 hours, and with practically no warpage cracks. On other shapes, drying has been speeded up to less than one-fourth the usual time without controls, and drying losses have been reduced to less than 0.5 per cent.

Figure 13 shows the relation between wet and dry bulb temperatures against time of drying heat.

High temperature ovens — Because of the higher temperatures existing in enameling and baking ovens, it is difficult or impossible to measure wet and dry bulb temperatures; for this reason very few humidity controls have been used on such applications, although manual methods are sometimes applied. At temperatures above 212 F, although the terms relative or percentage humidity have no physical meaning, it may be desirable to know the specific humidity conditions in order to determine drying power.

On certain installations, where close control is desired, but where the temperatures are too high to successfully operate a wet bulb; it has been proposed to use the absolute humidity controller described above to measure the drying conditions. Referring to Figure 7, if point A_3 represented the state of drying atmosphere, a knowledge of absolute humidity and furnace temperature would determine the state. If the corresponding furnace dry bulb temperature at A_3 were at 325 F, for example, by using the absolute humidity controller, the humidity measurement would be made by cooling along the constant humidity line A_3 B to a low dry bulb temperature where the corresponding wet bulb could be measured with reasonable accuracy. By controlling the absolute humidity and oven temperature, the desired drying conditions can be maintained.

On baking applications where the material is porous and contains very little water, drying rate is not important from the standpoint of preventing case hardening but the actual humidity content of the atmosphere may affect the baking operation and the physical strength of the product. The baking of foundry cores using oil binders is a good example of this.

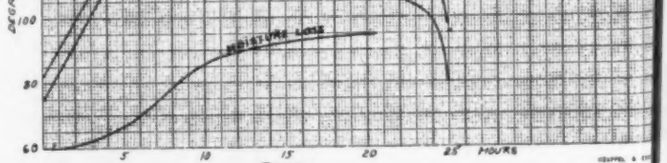
It has been proven by many tests that humidity affects the action of oil binders during the baking of sand cores, and that lower humidity produces greater tensile strength. Proper conditioning of the air passing through core ovens not only permits the foundryman to carry oil-sand ratio at the lowest point consistent in obtaining commercial cores, but also assures constant baking conditions. On modern ovens, a recirculating fan system and temperature control are the only means of regulation. It has been suggested that direct humidity control may be justified in large installations.

MISCELLANEOUS APPLICATIONS

There are a number of applications where it is desired to saturate, or nearly saturate, a space with water vapor. In some cases as in a bessemer converter or gas producer, the purpose of introducing moisture is to control process temperatures or, as in certain gas lines, to control dust and drying power of the gas.

Saturation control on gas producers — In the gas producer, steam is added to the air blast intake; while

Figure 13 — Curves show relationship between wet and dry bulb temperatures against time of drying heat for batch drier.



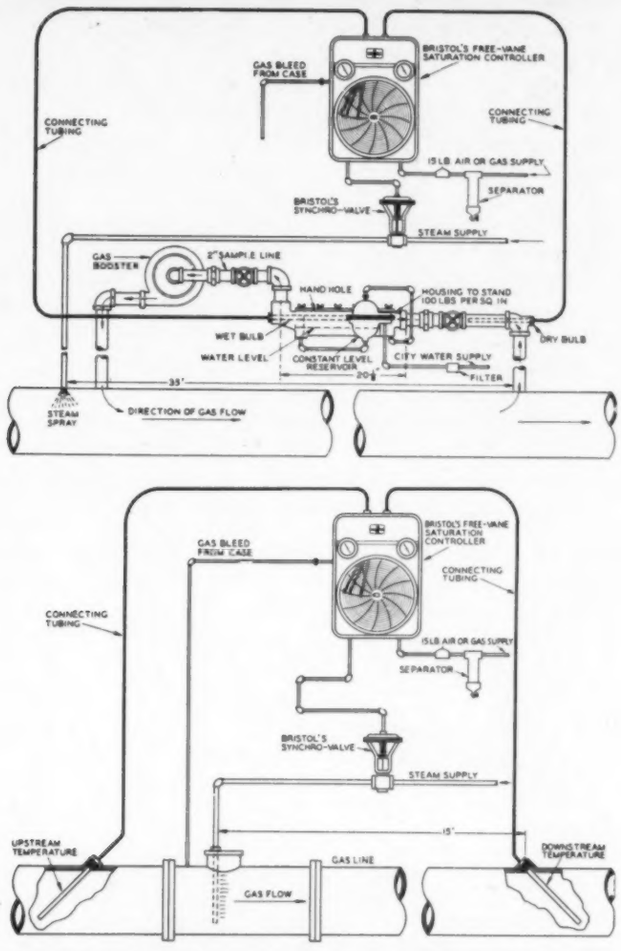


Figure 14 — Two schemes to measure and control moisture saturation in fuel gas lines are here illustrated.

steam affects the temperatures in the producer bed and consequently its efficiency in generating CO, a primary function of steam injection is to cinder the ash as it is melted in the ash zone. If the proportion of steam to air in the blast is too low, the fire will produce many clinkers and blow holes with resultant poor gas being generated. On the other hand, too much steam will give a dense ash bed which is also undesirable. Correct proportion of steam to air will result in the best porosity of the fuel bed, more equal distribution of pressure drop across the bed, which will give good conditions for the passage of air to permit best generation of carbon monoxide.

On early producers a simple indicating or recording thermometer was used with manual control of steam injection. The sensitive thermometer bulb was placed in the air blast main after the point of moisture injection. On most of the older installations steam was also used to induce air blast movement to the producer.

In recent years many producers have been equipped with turbo air blowers to move the air and with air operated thermometer controllers for saturation. The controllers are of the throttling type and operate a steam diaphragm control valve.

Although control practice varies somewhat depending upon the type of coal or other conditions, some operators secure best results by controlling the saturation line at 118 to 120 F which gives about 24 to 25 per cent CO. If the control is held at 130 F, a thicker fuel bed results with a lower CO content. Raising the control point to 135 or 140 F would result in a still thicker fuel bed with CO content of the gas dropping to about 19 per cent and lower.

Humidity control of fuel gas lines — About ten or fifteen years ago, many gas companies substituting the distribution of natural gas for manufactured gas found it desirable to saturate the relatively dry natural gas with water vapor and oil fog to prevent dust troubles and drying of pipe joints.

The gas is usually saturated with water vapor by emitting steam into the gas line at a point before it reaches the distribution system. Enough steam is mixed with the gas to maintain its relative humidity at slightly under 100 per cent at distribution temperature. Under these conditions the gas is unable to pick up moisture and to dry the joints. Since only enough moisture is added to the gas to saturate it, none will condense and collect in the drips.

In view of the fact that the gas load is continuously changing, it is almost impossible to control by hand the amount of steam added to maintain the desired humidity.

Figure 14 shows two methods of measurement and control of saturation in gas lines. In both methods a dual range chart is calibrated for dry bulb temperatures and another scale calibrated 10 to 0 F to show the depression of the wet bulb.

The controller automatically regulates the amount of steam or water spray added to the gas.

Within the past few years the trend on natural gas distribution lines has been to dry the air as much as possible, particularly on high pressure transportation lines where the smallest trace of moisture can cause trouble in freezing weather. Automatic control by direct measurement has not been possible because instruments capable of automatically measuring low dew points are unavailable.

DISCUSSION

PRESENTED BY

J. J. ALEXANDER, Assistant Superintendent Power, Republic Steel Corporation, Cleveland, Ohio

O. J. LEONE, Regional Manager, Steel Mill Division, The Bristol Company, Pittsburgh, Pennsylvania

J. J. Alexander: We have had some experience in controlling the moisture in the air to a blast furnace. In the several tests which we have conducted, we have used either a sling psychrometer or a wet-dry bulb temperature recorder to determine the absolute humidity of air to blower intake. While it is possible to obtain reasonable accuracy with these instruments, I agree with Mr. Leone that manual control of moisture is quite difficult due to rapid changes in the absolute humidity of the atmosphere. The effect of irregularities in moisture control depends upon the moisture level that is being maintained. When total moisture in the cold blast main was maintained at 4 grains per cubic

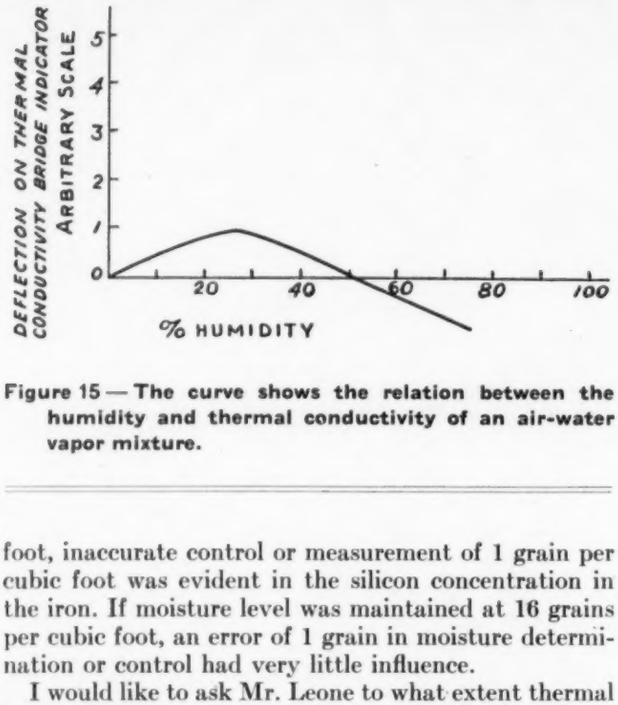


Figure 15 — The curve shows the relation between the humidity and thermal conductivity of an air-water vapor mixture.

foot, inaccurate control or measurement of 1 grain per cubic foot was evident in the silicon concentration in the iron. If moisture level was maintained at 16 grains per cubic foot, an error of 1 grain in moisture determination or control had very little influence.

I would like to ask Mr. Leone to what extent thermal conductivity instruments can be used for the determination of absolute humidity, and whether this type of instrument would be feasible in blast furnace moisture control.

O. J. Leone: There has been some work done with thermal conductivity instruments, but unfortunately, when used to measure the moisture content of air, some trouble has been experienced. I can best illustrate what I mean by a representative curve given in Figure 16 showing the relation between humidity and arbitrary deflection values on a conductivity bridge indicator.

The first difficulty one gets into is due to the peculiar shape of the deflection — humidity curve. Another difficulty in measuring humidity content of air by thermal conductivity methods has been due to the small change in thermal conductivity corresponding to the normal changes in relative humidity in which one is usually interested. For example, looking at the problem from a measurement viewpoint, the equivalent millivolts change corresponding to a change from the arbitrary zero abscissa line to the peak in the curve is only a few millivolts. The other problem arises from the peculiar reversal of the curve. For example, by examining the curve it can be seen that at the peak where there is little or no slope, a point of minimum meter sensitivity is reached. In addition, because of the reversal of slope, it can be seen that at certain temperatures the reading is ambiguous, since a given conductivity may correspond to either of two values.

On certain other gases, for example nitrogen or hydrogen, one obtains a much better curve, which continues in one direction without reversals. With these gases, one obtains a much larger change in millivolts or thermal conductivity for corresponding normal changes in humidity. Other methods that have been tried include ionization; and quite a bit of work has been done within the last few years, but not enough has been done to make this method practical as yet so far as I know.

Another idea that has been tried is to measure humidity by permittivity or specific inductive capacity of water vapor, which values are rather large as compared to dry air. The ratio of the dielectric constants of water vapor and air are about 80 to 1, which means that a relatively small change in water vapor results in an appreciable change in the dielectric constant for the mixture. One trouble with all indirect methods, however, is that one is certain of the measurement only in the case of single component gases; with complex mixtures, the thermal conductivity, or dielectric constant, (or whatever variable is being measured), of the other components affect the relationship of the mixture and render the measurement difficult.

Among the other methods that have been tried recently has been a combination of a chemical — electrical method that uses lithium salts on a surface over one leg of a resistance bridge. I do not know of any such instrument now being used in the steel industry, although the idea has been tried unsuccessfully.

J. J. Alexander: The absolute humidity curve would be of the same shape as the relative humidity curve in that case.

O. J. Leone: The thermal conductivity instrument actually measures percentage humidity, I am fairly certain. As to the actual similarity of the curves, I do not recall, offhand, whether or not the shapes of the curves are the same.

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Tailored Motors

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by L. W. Herchenroeder

WESTINGHOUSE ELECTRIC CORPORATION

EAST PITTSBURGH, PENNSYLVANIA

▲ DUTY cycle applications of squirrel cage motors are not new. Ordinarily these are thought of as requiring frequent starting, stopping, reversing, and on multi-speed motors, changing from one speed to another. The only way to apply a motor accurately for a duty cycle is to calculate the losses in the motor for the various portions of the cycle and see if the losses are within the amount the motor can dissipate with a safe temperature rise. Though such a procedure requires data available only to a motor designer, it is possible to get a picture of the severity of a duty cycle without detailed motor design information.

The torque the motor must deliver during acceleration may be considered to consist of two components, one of which supplies the running load and the other the acceleration of the inertia. On many duty cycle applications the running torque is small compared to the accelerating torque and may be neglected for estimating purposes. The problem then becomes one of determining losses in an induction motor during the accelerating or stopping of an inertia load.

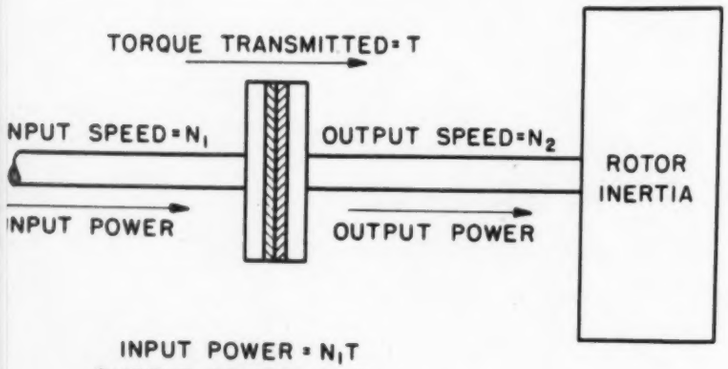
An induction motor consists of a stator winding that creates a magnetic field rotating at synchronous speed and a rotor that operates at some slip speed with respect to the rotating magnetic field. As far as acceleration is concerned, an analogy can be made with a friction clutch in which one plate represents the rotating magnetic field, and is driven at constant speed equal to the synchronous speed of the motor, and the other plate represents the rotor and runs at the rotor speed. Figure 1 illustrates this analogy. The rotor inertia will be considered to include the inertia of the rotor plus the inertia of all connected rotating parts. It is assumed that no running load is present.

The input power is equal to the speed of the input shaft multiplied by the torque transmitted by the clutch. The output power is equal to the speed of the output shaft multiplied by the torque transmitted by the clutch. The loss in the clutch is equal to the difference between the input and the output power and is, therefore, equal to the difference between the input and output speeds multiplied by the torque transmitted through the clutch. The difference between the input and output speeds is known as the slip speed and, therefore, it can be seen that loss in the clutch is equal to the slip speed multiplied by the torque transmitted. The friction loss in the clutch represents the I^2R loss in the rotor.

From a paper presented at Machine Tool Forum, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, April 9, 10, 1946.

The torque transmitted by a friction clutch will be approximately constant regardless of the speed. The torque developed by the rotor of an induction motor varies considerably with speed; however, the energies involved during speed changes will be the same if the torque is considered to be constant.

Figure 2 shows the application of the analogy to the acceleration of an inertia load from zero to synchronous speed. At zero speed of the output shaft, the output power is zero and, therefore, the entire input power is lost in the clutch. At synchronous speed the output power equals the input power and there is no loss in the clutch. At intermediate values of speed the loss in the clutch is proportional to the difference in speed of the input and output shafts. The power lost in the clutch is, therefore, given by the straight line drawn from A to C and the total energy lost in the clutch during acceleration is given by the area ACO. The total energy delivered to the rotor inertia is given by the area ABC. It can be seen that the total energy lost in the clutch is equal to the total energy delivered to the rotor inertia which gives the well-known result that the loss in the rotor of an induction motor during acceleration is equal to the stored energy of the rotor inertia.

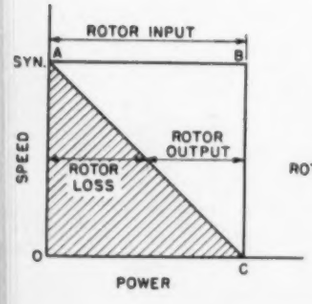


INPUT POWER = N_1T
OUTPUT POWER = N_2T
LOSS IN CLUTCH = ROTOR LOSS
$= N_1T - N_2T$
$= (N_1 - N_2)T$

Figure 1 — Friction clutch analogy of acceleration of an induction motor presents graphically the principles of an induction motor.

▲

Figure 2 — Analogy of acceleration of an inertia load from zero to synchronous speed shows that the rotor loss is equal to the rotor stored energy in an induction motor.



ROTOR STORED ENERGY = INERTIA x $\overline{RPM}^2$
= AREA ABC

ROTOR LOSS DURING ACCELERATION = AREA ACO
= ROTOR STORED ENERGY

There are, of course, losses in the stator of an induction motor as well as in the rotor. The stator losses may be separated into two components consisting of the I^2R losses and the excitation losses. The excitation losses will be approximately constant regardless of speed while the I^2R loss will be proportional to the rotor loss. The ratio of the stator I^2R loss to the rotor loss is equal to the ratio of the stator resistance to the rotor resistance.

It has been shown above, that the rotor loss during acceleration must be equal to the stored energy of the rotor inertia. In order to reduce the losses during acceleration, therefore, the only thing that can be done is to try to reduce the stator losses. This can be done by reducing the ratio of the stator resistance to the rotor resistance. It is not possible to reduce the stator resistance appreciably and, therefore, the only way to change the ratio is to increase the rotor resistance. This results in a high slip motor which is the preferred type for frequent acceleration.

Figure 3 shows the rotor losses that occur during plugging to a stop or during a plug reversal. At the start of plugging the rotor is running at minus synchronous speed and the difference in speed between the two clutch plates is equal to twice synchronous speed. Since the torque transmitted is constant and the loss is equal to the product of the torque times the difference in speed, the rotor loss is equal to twice that obtained at zero speed of the rotor. If the rotor loss is plotted against the speed the straight line ACD is obtained. The total energy loss in the rotor is given by the area ADF. The energy stored in the rotor when running at synchronous speed is equal to area ABC. It can be seen from the figure that the area ADF is 4 times as large as the area ADC which means that the loss in the rotor during a plug reversal is equal to four times the stored energy of the rotor inertia. The loss during a plug stop is given by the area OCDF. This means that the loss in the rotor for a plug stop is equal to three times the stored energy of the rotor inertia.

It will be noted that the area CDE is equal to ABC which represents the stored energy of the rotor at synchronous speed. The area CDE represents the energy stored in the rotor at the start of plugging. The loss represented by area CDE, therefore, comes from the stored energy of the rotor and the loss represented by the area ACEF comes from the power lines.

Suppose a two-speed motor is plugged from high speed in one direction to half speed in the opposite direction. Figure 4 shows the loss that occurs in this case. If the rotor losses are plotted the straight line ACD is obtained. Area ADF represents the rotor loss when plugging from full speed to half speed in the other direction. The stored energy of the rotor at the beginning of plugging is represented by the area CDE. By

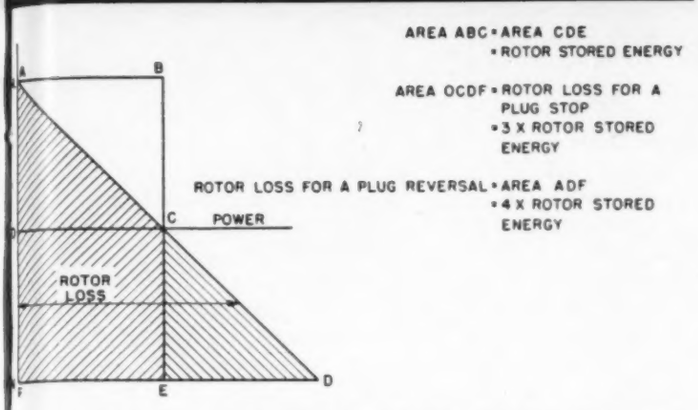


Figure 3 — Rotor losses during plugging to a stop or during a plug reversal in an induction motor are respectively three and four times the rotor stored energy.

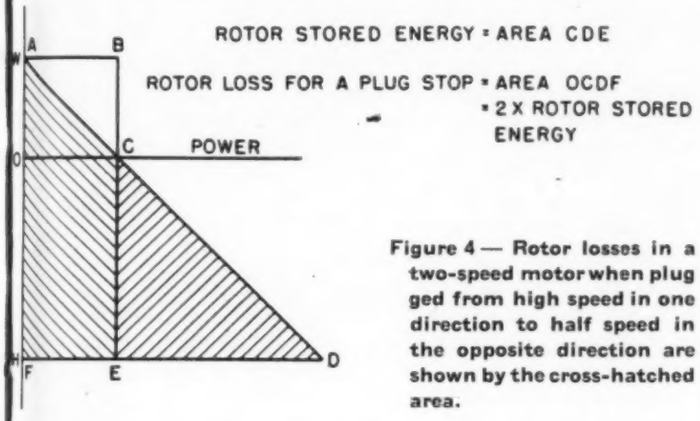


Figure 4 — Rotor losses in a two-speed motor when plugged from high speed in one direction to half speed in the opposite direction are shown by the cross-hatched area.

comparing areas, it can be seen that the loss in the rotor is equal to 2¼ times the stored energy of the rotor. For a plug stop the rotor loss is equal to two times the stored energy of the rotor. If a two-speed motor is plugged to a stop, a rotor loss will result that is equal to two times the rotor stored energy if plugged on the low speed winding as compared to three times the rotor stored energy is plugged on the high speed winding.

Figure 5 illustrates the loss involved in a two-speed motor when going from high to low speed by regenerative braking. At the first instant after changing from the high to the low speed winding, the rotor is revolving at twice synchronous speed. In the clutch analogy this is equivalent to the rotor plate revolving twice as fast as the stator plate. The speed of the stator plate equals the slip speed of the rotor plate and the rotor loss at high speed is equal to the stator power. In Figure 5 the rotor loss at high speed is represented by AB and the stator power by BC. Since the rotor plate is tending to drive the stator plate the torque transmitted by the clutch is reversed from the normal motoring direction and the stator power is regenerated. The power regenerated will remain constant with respect to speed while the rotor loss will be equal to the horizontal distance between the lines BD and AD. The stored energy of the rotor is represented by the area ACO. The loss in the rotor when regenerating from high to low speed will be represented by the area ABD and is equal to ¼ the stored energy of the rotor. The power regenerated is represented by the area BCED. This is equal to ½ the stored energy of the rotor. The area DEO represents the remaining energy stored in the rotor at half speed and is equal to ¼ of the energy stored in the rotor at top speed.

Figure 6 illustrates the losses involved in a four-speed motor during regenerative braking. Assume that the rotor is at high speed and the stator is suddenly connected for ¾ speed. The rotor slip speed is then ⅓ of the stator speed and the rotor loss is ⅓ of the stator power. In Figure 6, AB represents the rotor loss and BC the stator power regenerated. Area ABD represents the rotor loss and area BCFD the regenerated energy while braking regeneratively from high to ¾ speed. Area ACO represents the stored energy of the rotor at high speed. Comparing areas, the rotor loss is found to be 1/16 and the regenerated energy ⅜ of the stored energy of the rotor at top speed. If the motor is braked to half speed in two steps the rotor loss will be ⅛ of the rotor stored energy. This is ½ of the rotor loss that

Figure 5 — Rotor losses in a two-speed motor when going from high to low speed by regenerative braking are equal to ¼ the rotor stored energy.

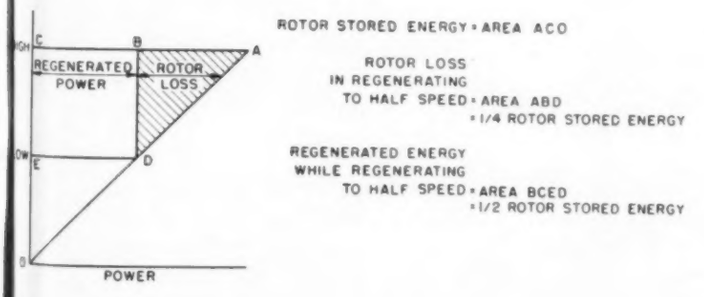
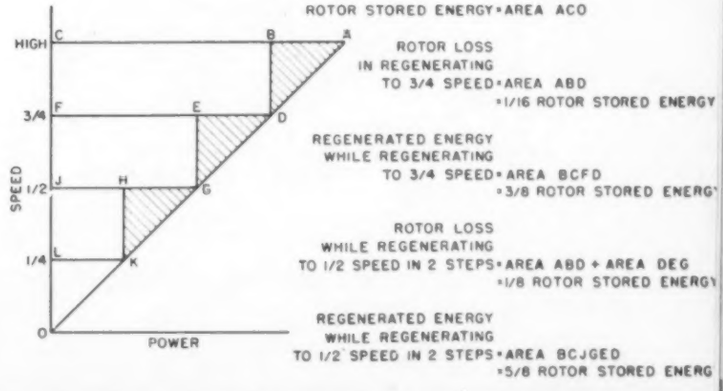


Figure 6 — Rotor losses in a four-speed motor going from high to ¾ speed by regenerative braking are shown on this diagram.



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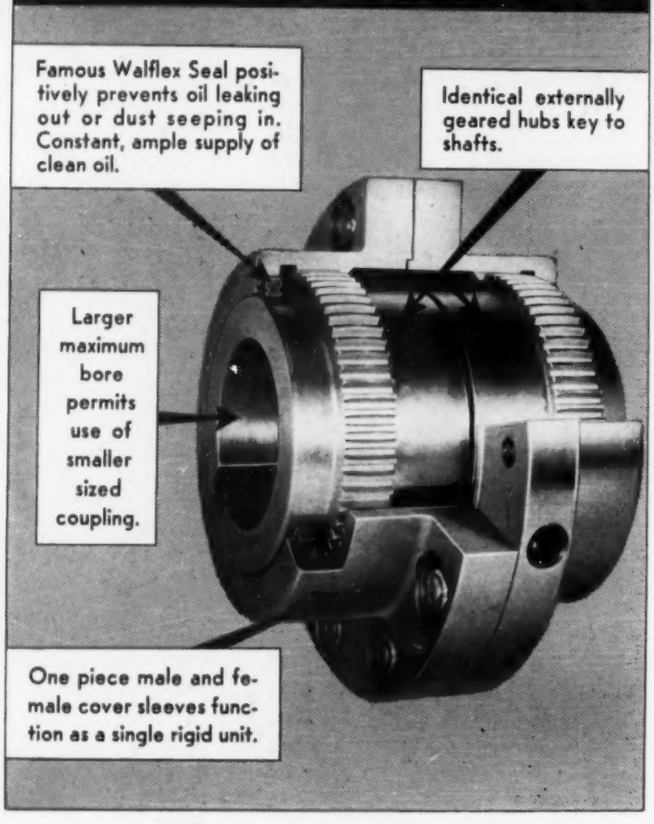
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occurs when regenerating to half speed in one step as shown in Figure 5.

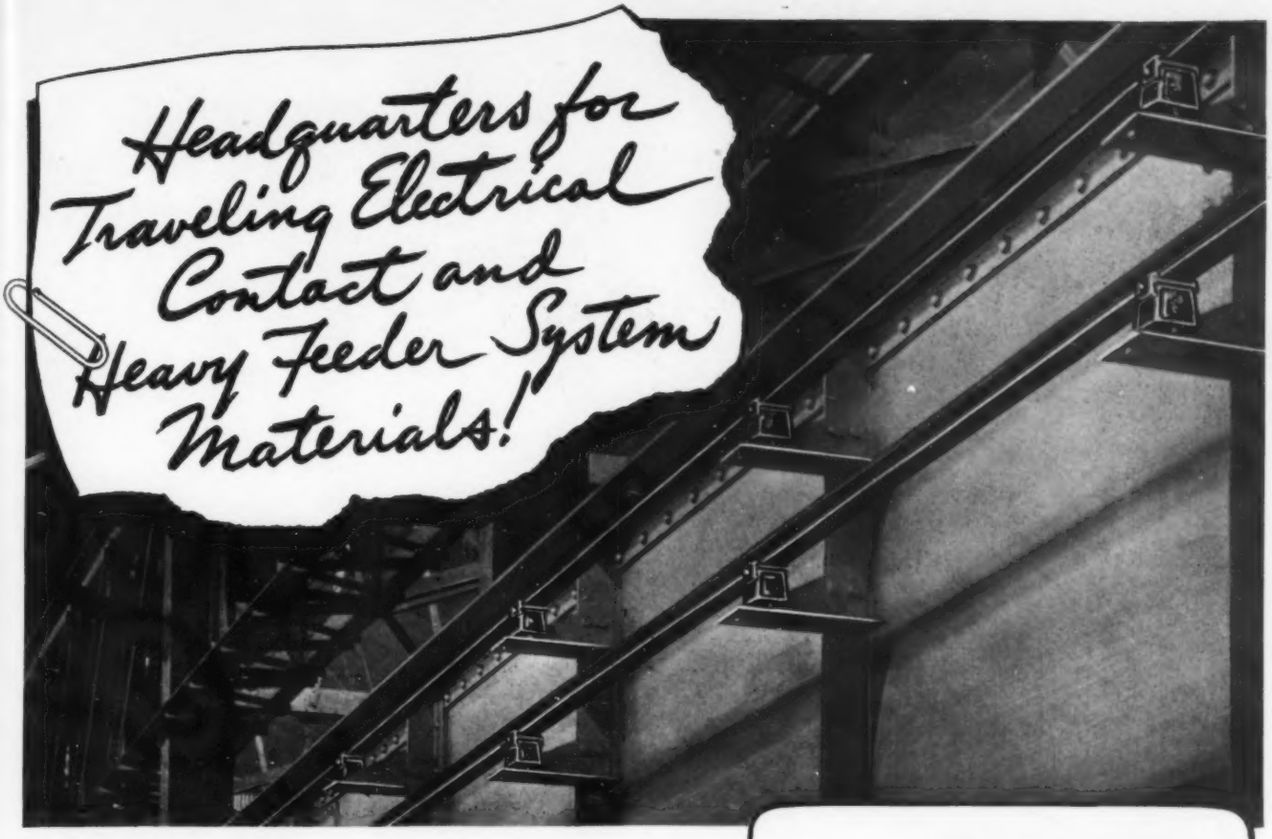
In all of the above examples, the losses in the rotor depend directly on the amount of inertia connected to the motor shaft. In designing a machine for duty cycle operation, the rotating parts such as sheaves, gears, chucks, etc., should be designed to have the minimum inertia when referred to the motor shaft. The inertia of these parts can often be reduced considerably by suitable design. The importance of this point cannot be over emplasized as the number of cycles per hour of which the motor is capable depends largely on the stored energy of the rotating parts.

Ventilation of the motor is an important factor on duty cycle applications. The losses an open motor can dissipate drop off considerably with speed due to a decrease in the amount of air forced through the motor. A motor that starts and stops, or reverses frequently, may have a low average speed which with the high losses will cause the motor to overheat. Assuming that everything possible has been done to decrease the losses during the cycle, the only alternative is to increase the ability of the motor to dissipate its losses. Forced ventilation is the obvious answer. It is very likely that forced ventilation will be used on many of the more difficult applications.

A word of caution is probably in order at this point. If a motor overheats on an ordinary application the natural reaction is to put in a larger motor. This does not necessarily work on duty cycle applications. For example, consider a reversing application with negligible connected inertia and running load. Increasing the motor rating will result in a decrease in the number of reversals obtained. The reason for this is that as the motor frame size is increased, the stored energy in the rotor increases faster than the dissipating ability of the motor.

Another recommendation is not to use Class II motors on duty cycle applications. These motors have a double cage rotor construction and are intended for applications requiring infrequent starting, high starting torque, and good running characteristics. The double cage construction consists of large, low resistance bars imbedded deep in the iron and small high resistance bars near the surface of the rotor iron. At low speeds the small bars carry most of the rotor current, thus giving a high resistance characteristic for starting. At high speeds the large bars carry most of the current, thus giving a low rotor resistance for good running characteristics. Most of the rotor starting losses are concentrated in the small bars, and if the motor is started or reversed frequently the rotor will fail mechanically due to unequal expansion of the large and small bars.

A few of the fundamentals on the use of squirrel cage motors on duty cycle applications have been reviewed. the important point is to recognize the types of operation that cause high motor losses, such as; accelerating, plugging, and regenerating, and to check the application with a motor designer if these operations occur frequently.



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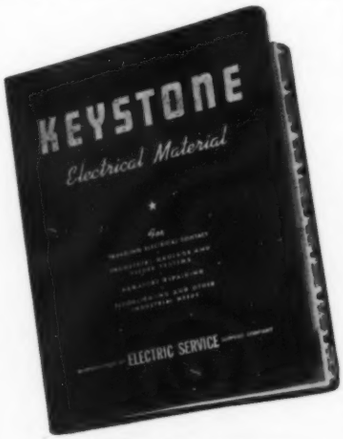

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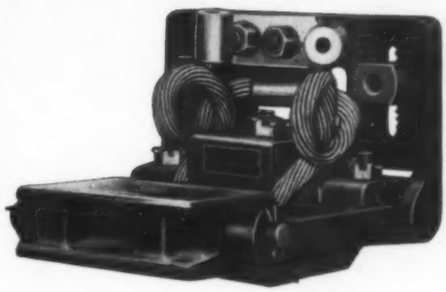

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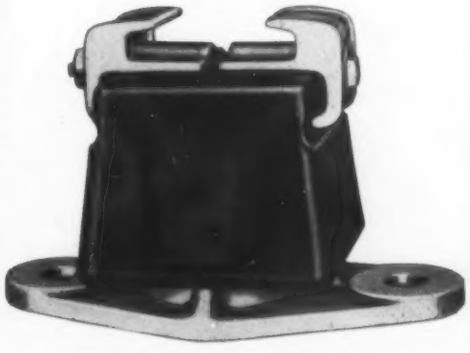

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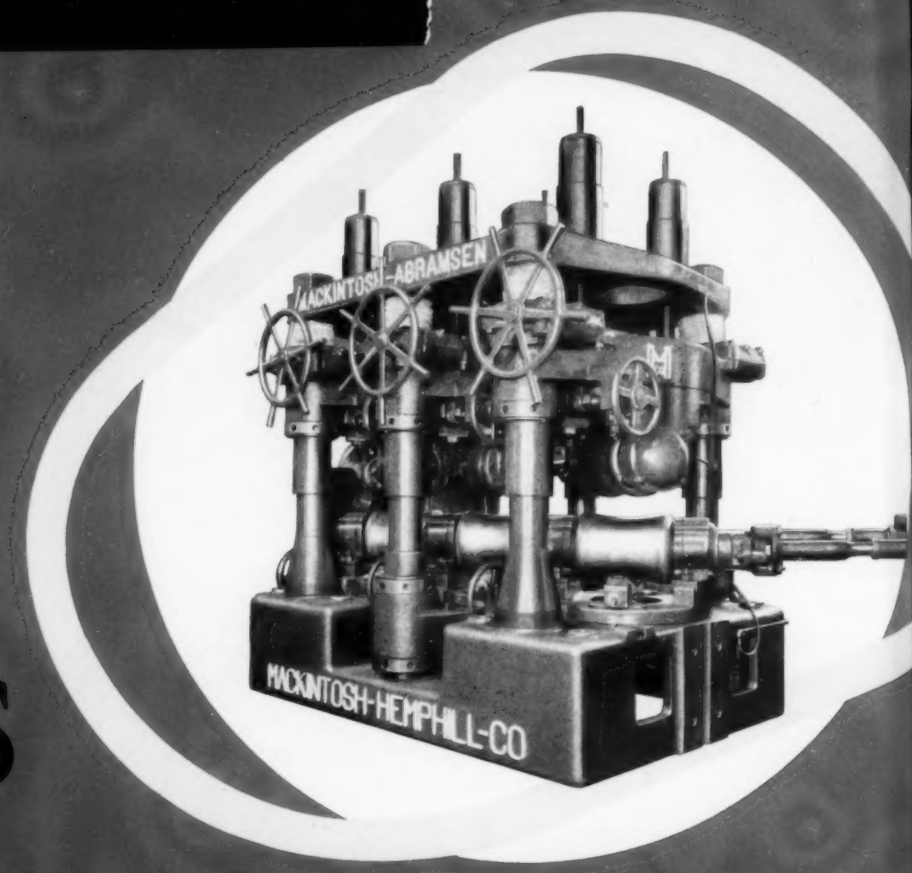
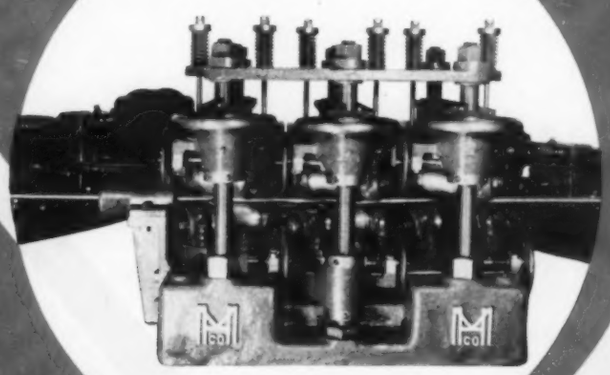


cuts setting-up operations

In these improved Mackintosh-Abramsen straighteners guides have been eliminated, preventing ringing and scoring of stock. Stock action and exact quality of finish are controlled by three pairs of rolls . . . the outer pairs fixed and the inner pair offset, utilizing a balanced arrangement of drives. The bending action on stock is continuous, from section to section rather than point to point, eliminating end bends. Thus distributing the cold work uniformly over the entire length of the bar or pipe. Design has been so simplified that adjustments and roll changes are much easier to make.

Here is a straightener that will speed up production, cut operating costs, and deliver an absolutely straight product—from end to end. Just another example of Mackintosh-Hemphill's advanced industrial thinking.

Mackintosh-Abramsen straighteners are made to handle ferrous or non-ferrous tubing from 1/16" to 24" diameters and bars from 1/8" to 8 1/2" diameter.



...sin half

...ckintosh-Hemphill Company

PITTSBURGH AND MIDLAND, PENNSYLVANIA

...takers of the Rolls with the Red Wabblers

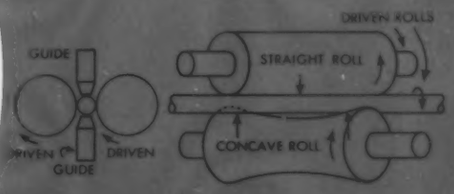
It will

- ✓ Reduce setting-up operations from 31 to 16
- ✓ Give you a straighter product—hot or cold
- ✓ Give you a smoother, cleaner product
- ✓ Increase production rates
- ✓ Remove out-of-roundness
- ✓ Lower production costs
- ✓ Remove end bends

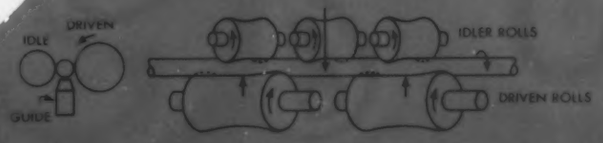
It won't

- X Spiral-mark thin wall tubes or soft material
- X Destroy the surface on coated materials
- X Guide-score finished material
- X Unduly harden ductile metals

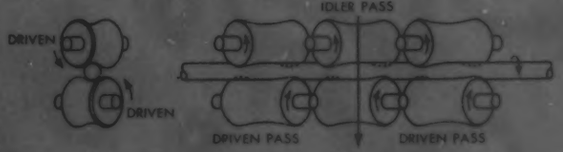
Here's why:



One current method of straightening is done in one set of cross rolls. Guides are used to hold material on the pass line. The straightening takes place from point to point on the rolls and against the guides. Efficiency drops with wear on the rolls.



A second current method of straightening is done by a pressure roll between two cross roll passes. Material is held on the pass line by a bottom guide. The straightening takes place from point to point on the rolls and against the guide. Efficiency drops with wear on the rolls.



The Mackintosh-Abramsen method of straightening is accomplished by an offset cross roll pass between two fixed cross roll passes (patented). No guides are required because the rolls are driven on both sides of the material which is supported by the bottom rolls. With this balanced arrangement there is no decreasing efficiency from uneven wearing of the rolls. The straightening takes place from section to section and not from point to point.

SPECIFICATIONS ALONE DO NOT MAKE A WORM GEAR

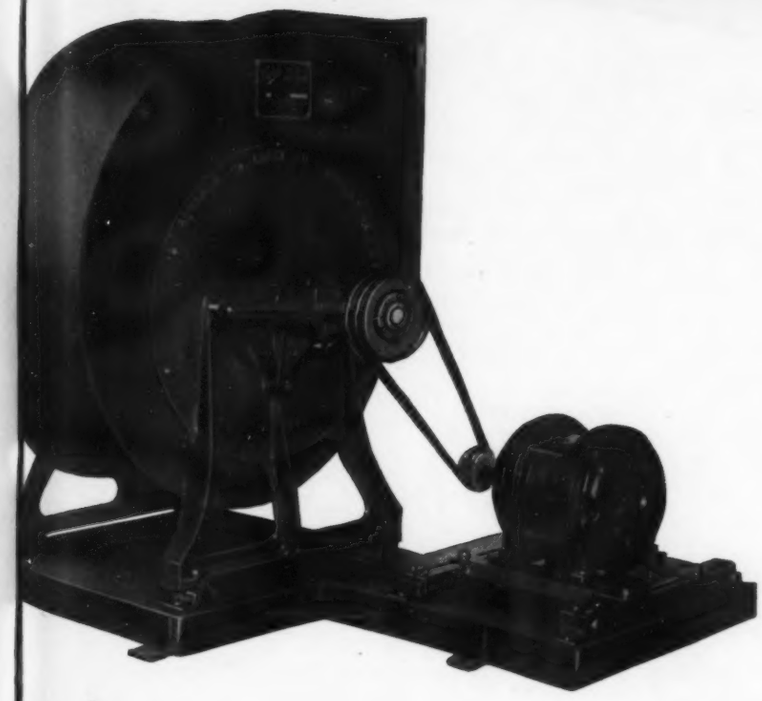
Controlled Atmosphere Hardening

INCREASES *Life of* DE LAVAL *Gears*

The extremely long life of De Laval Worm and Gear sets is due, in part, to the heat treatment to which the worms are subjected. Made from carefully selected alloy steel, De Laval worms are case hardened in the most modern, controlled atmosphere, forced convection, electric furnaces under careful metallurgical inspection and control. The heat treatment process employed provides a hard, uniform case and correct core structure of high tensile strength, free from internal stresses.

WG-2

Sure Cure for Exhaust-Fan Headaches!



Many plant superintendents will welcome the new Buffalo Industrial Exhauster when they see HOW it is built. Here is a fan to take the hardest kind of industrial service without let-up.

Heavy all-welded housing, heavy shaft, oversize bearings, two efficient new all-welded rotors, one for air handling, one for material handling---a complete range of sizes for direct connection to electric motor or belt drive---you can put this fan on the "headache job" with assurance that your troubles are over.

Bulletin 3576 gives complete details.

his new data book gives omplete construction etails and ratings on e efficient new "Buffa-" Industrial Exhauster.

BUFFALO FORGE COMPANY

173 Mortimer St. **Buffalo, N. Y.**

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo" NEW! INDUSTRIAL EXHAUSTERS

FUSETRONS

—Prevent Needless Shutdowns,

Here's Why

Fusetrons have a tremendous time-lag—far greater than ordinary fuses—due to the combining of a fuse and a thermal cutout.

Here's how time-lag of Fusetrons compares with that of ordinary fuses.

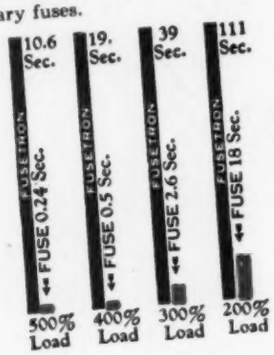


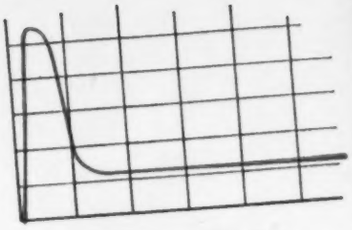
Chart shows 30 amp. 250 volt fuses. Other sizes and 600 volt ratings show similar results.

The great time-lag of Fusetrons permits them to hold harmless overloads and keep circuits in operation instead of opening and causing useless shutdowns.

Ordinary fuses or other forms of protective devices *cannot* do this job.

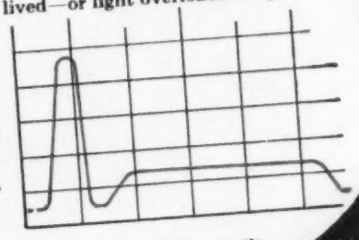
FOR EXAMPLE

AC motors require a current of 3 to 9 times their rating for starting. This high starting current often causes ordinary fuses to open.



Fusetrons Have the Capacity to Absorb This High Starting Current Without Opening—even where type of load causes starting current to hang on.

In normal operation overloads often occur that are heavy but short lived—or light overloads hang on. In either instance they are harmless—yet they often cause ordinary fuses or other forms of protective devices to open.



Fusetrons Will Hold Such Harmless Overloads —and Keep the Circuit in Operation.

LIKEWISE

• • INSTALL FUSETRONS THROUGHOUT THE PLANT TO GET

★ ***Entirely wipe out needless blows caused by motor starting currents or other harmless overloads.***

(*See above*)

★ ***Give Thermal Protection to Panelboards and Switches***

The thermal cutout in the Fusetron will open whenever its temperature reaches 280° F. Thus if poor contact heat develops from any cause the Fusetron cuts off the current before damaging temperatures can be reached.

Ordinary fuses can't so protect because the temperature of the link must reach 786° F. before it will melt out.

With Fusetrons you are warned that a minor maintenance job is needed instead of having panel or switch damaged or destroyed by poor contact.

★ ***Prevent Needless Blows Caused by Heating in Panels and Switches***

Ordinary fuses have 55 to 140% greater electrical resistance at full load than Fusetrons, hence Fusetrons produce less heat and thus eliminate useless shutdown troubles caused by fuses running too hot in panelboards and switches.

★ ***Permit Use of Larger Motor or Adding More Motors on Circuit WITHOUT Installing Larger Switch or Panel***

The operating load on Fusetrons can be close to their ampere rating because Fusetrons hold starting currents. But ordinary fuses must be installed oversize because they lack sufficient time-lag to hold starting currents.

By replacing oversize fuses with Fusetrons, you can load panels or switches to near capacity. A large motor or additional motors can be installed without the trouble or expense of changing the panel or switch.

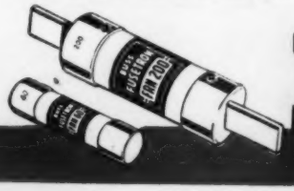
★ ***On New Installations PROPER Size Switches and Panels Can Be Used Instead of OVERSIZE***

With ordinary fuses, switches and panels must be oversize because fuses larger than the operating load must be used to hold starting currents.

But Fusetrons hold starting currents, therefore, PROPER size switches and panels to fit the load can be installed, saving money and space.

★ ***Protect motors against burnout***

On normal installations, Fusetrons used in a size near ampere rating of motor will protect it against burnout from lack of oil, worn bearings, tight belt or anything that causes a dangerous electrical overload—yet their tremendous time-lag keeps them from blowing on motor-starting current.

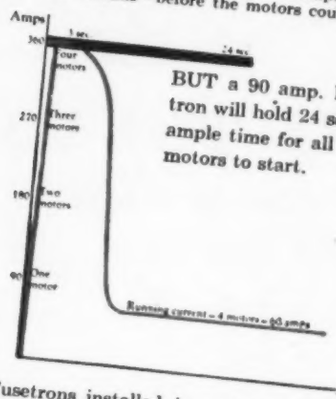


BUSS

Hold Harmless Overloads
without Sacrificing Protection

This tremendous time-lag will also prevent needless blows on MAINS AND FEEDER CIRCUITS. Even if all motors on the circuit start at one time—Fusetrons will not open. For example: four 15 ampere motors on a circuit would ordinarily be protected by 90 ampere fuses.

If these four motors start at one time and the starting current of each motor is 90 amperes, the combined starting current is 360 amperes. At this load a 90 ampere fuse would open in about 3 seconds—before the motors could start



BUT a 90 amp. Fusetron will hold 24 sec.—ample time for all four motors to start.

SO with Fusetrons installed in mains, feeders and all branch circuits—shutdowns caused by the needless opening of fuses or other forms of protective devices on motor starting currents or other harmless overloads are *entirely wiped out.*

HERE'S PROOF

"Fusetrons Saved Us a Lot of Money and Trouble on Our Crusher Circuit"—*Paul G. Nunn, Manager, The Nunn Company, Overton, Nevada.*

Mr. Nunn continues, "In April, 1942, we installed a crusher powered by a 40 h. p. motor. Ordinary fuses were installed. We had trouble from the beginning as the fuses would blow out almost as fast as we could put them in. We were advised that the motor was too small and it was recommended that a 60 h. p. motor be installed. The cost of the new motor and larger feeders we were told would amount to about $2,000.00.

"We were about to go ahead, however, as the shutdowns were costing us about $20.00 per day in labor alone not to speak of loss in production.

"My brother, however, sent us a set of Fusetrons and suggested we try them out. We did. Much to my surprise when the power was thrown on the Fusetrons held. This was nearly two years ago and we have not had a Fusetron blow.

"I feel that you should know that Fusetrons saved us a lot of money and a lot of trouble. We are changing over to Fusetrons throughout our plant."

MANY KINDS OF PROTECTION HERETOFORE NOT AVAILABLE

★ ***Give DOUBLE burnout protection to large motors***

Larger motors already equipped with overload protection sometimes burn out due to thermals or relays failing to operate. Replace fuses used for short-circuit protection with Fusetrons of size near motor rating and they will protect motor against burnout from any electrical overload, entirely independent of other overload device.

★ ***Provide simplest way to stop burnouts from single phasing***

When single phasing occurs, increased current flowing through remaining phase will open Fusetrons (if size used is near the rating of the motor) and shut down motor. Never before has such dependable single phasing protection been available.

★ ***Make burnout protection of SMALL motors simple and inexpensive***

Small motors have generally been operated without burnout protection because the cost of protecting them has been too great compared to cost of replacing motor. Now for the little cost of installing a Fusetron of proper size, any motor can be given safe, dependable burnout protection.

★ ***Protect Coils, Transformers and Solenoids against burnout***

Install a proper size Fusetron. It won't open on harmless overloads or normal current surges, yet should a dangerous overload occur for any reason it will cut off the current to prevent a burnout.

Get All the Facts

★ ***GET BETTER PROTECTION—SEND THE COUPON NOW***

Even one lost motor or one needless shutdown or one destroyed panel may cost you more than replacing every fuse with a Fusetron. Don't risk such losses, change over the whole plant to Fusetrons.

BUSSMANN MFG. CO., University at Jefferson • St. Louis 7, Mo.
Division McGraw Electric Co.

FUSETRONS
SOLD THROUGH WHOLESALERS

BUSSMANN MFG. Co., University at Jefferson
St. Louis 7, Mo. (*Division McGraw Electric Co.*)
Please send me complete facts about BUSS Fusetrons.

Name_____
Title_____
Company_____
Address_____ State_____
City_____

Wapakoneta SHEAR BLADES and SLITTERS ...

ENGINEERED FOR THE JOB

MORE THAN 50 YEARS of Service

THEY HOLD THE EDGE

because they are tempered and ground for your particular needs

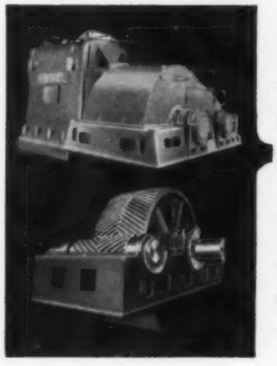
Wapakoneta Shear Blades are made and heat treated, ***not*** to meet some universal standard of our own, but to best fill each customer's requirements... That is why Wapakoneta Shear Blades stand up longer on the job and cut more tonnage.

The Wapakoneta Machine Company

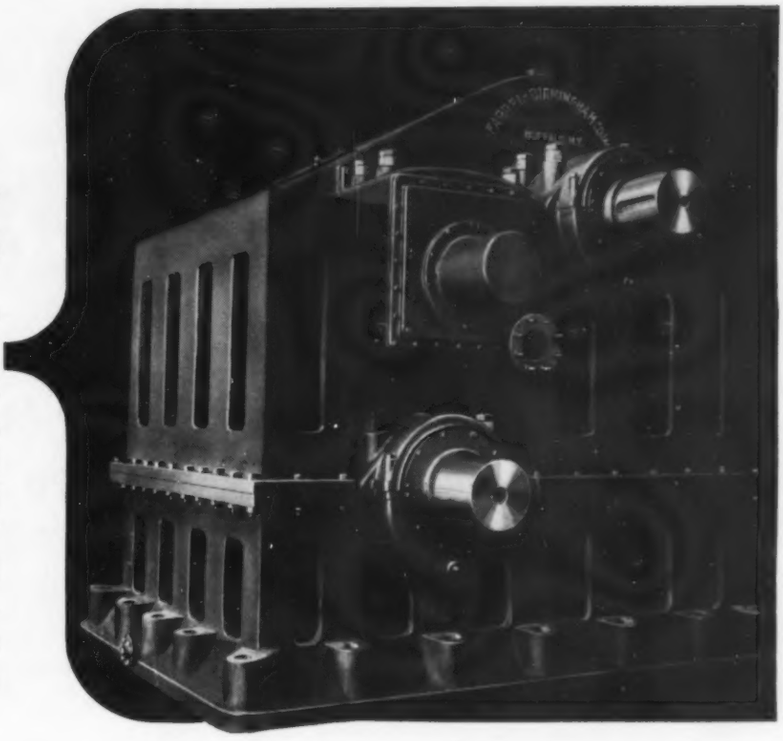
INCORPORATED 1891 — Wapakoneta, Ohio U.S.A.

RUGGED INDIVIDUALISM

IS VITAL IN MILL DRIVES



A rolling mill drive must be both **RUGGED** - - - - - - - - - (strong enough to withstand shocks and stresses it will encounter), and **INDIVIDUALISTIC** (designed and built to fit the specific requirements of the job it has to do).



Here's how "rugged individualism" is applied as a design principle in Farrel-Birmingham mill drives:

1. Every vital part of a Farrel unit is of a size and material which provides fully adequate strength to withstand the stresses, strains and shocks to which it will be subjected.

2. Farrel drives are *engineered for the job.* Power and speed to be used...type and gauge of metal to be rolled . . . process (hot or cold) . . . nature of load (continuous or intermittent) . . . type of drive motor . . . all these influencing factors are taken into account in designing a Farrel mill drive.

Next time you need a mill drive to fit a particular job, call on Farrel. Complete information and engineering help are yours for the asking at any time.

FARREL ROLLING MILL MACHINERY

Rolls	Mill Pinions
Rolling Mills	Pinion Stands
Rod Mill Tables and Manipulating Equipment	Gear Drives of any Capacity
Universal Mill Spindles	Flexible Couplings
Rod Coilers	Roll Grinding Machines
Gears	Roll Calipers
	Lead Presses for Pipe or Rod

FB-320

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ANSONIA, CONN.

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Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Los Angeles, Tulsa, Houston, Charlotte

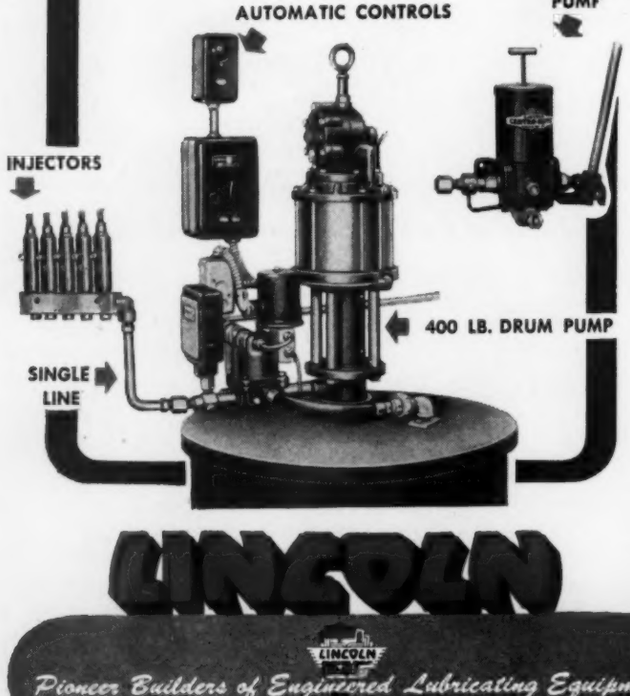
Farrel-Birmingham

LINCOLN
CENTRO-MATIC
Single Line LUBRICATING SYSTEMS
Save Bearings, Machine Hours, Man Hours, Power and Prevent Accidents...

Today, throughout industry, Lincoln Centro-Matic Lubricating Systems are increasing bearing life on a wide variety of machinery and are helping to insure uninterrupted production.

These outstanding centralized systems are designed for simplicity and dependability. They are easy to install on new machines or old machines and consist of a number of injectors — one for each bearing, and a single lubricant supply line from the lubricant pump to each injector. The pump can be time clock or push-button controlled, power operated, or manually operated. One lubricant pump can supply lubricant for a single machine or a battery of machines.

Lincoln Engineering Company maintains a staff of experienced lubrication engineers prepared to assist you with all of your lubricating problems. Mail the coupon for complete information.



LINCOLN

Pioneer Builders of Engineered Lubricating Equipment

A Few of the Hundreds of Machines Now Equipped with LINCOLN Centro-Matic Lubricating Systems...

- ☐ Angle Shears
- ☐ Agitators
- ☐ Bottling Machinery
- ☐ Brick Presses
- ☐ Boats
- ☐ Bolters
- ☐ Boring Machines
- ☐ Bar Mills
- ☐ Bar Straighteners
- ☐ Back Geared Presses
- ☐ Brake Presses
- ☐ Cranes
- ☐ Crimpers
- ☐ CenterlessGrinders
- ☐ Candy Machinery
- ☐ Cutters
- ☐ Chemical Machinery
- ☐ Cold Roll Mills
- ☐ Conveyors
- ☐ Coal Loaders
- ☐ Coke Quenching Cars
- ☐ Chip Stokers
- ☐ Crushers
- ☐ Caramel Cutters
- ☐ Cookers
- ☐ Coilers
- ☐ Dry Presses
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- ☐ Duplicators
- ☐ Die Casters
- ☐ Draw Benches
- ☐ Electric Shovels
- ☐ Forging Machines
- ☐ Forming Presses
- ☐ Filter Presses
- ☐ Filtering Equipment
- ☐ Grain Presses
- ☐ Grinders
- ☐ Hydraulic Presses
- ☐ Lathes
- ☐ Locomotives
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- ☐ Mine Tipples
- ☐ Metal Reclaimers
- ☐ Pasting Machinery
- ☐ Punch Presses
- ☐ Printing Presses
- ☐ Plastic Presses
- ☐ Processing Machinery
- ☐ Packaging Machinery
- ☐ Plate Shears
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- ☐ Rolling Mills
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- ☐ Spacing Machines
- ☐ Starch Bucks
- ☐ Screw Conveyors
- ☐ Slab Mills
- ☐ Shears
- ☐ Tube Coiling Machines
- ☐ Tow Boats
- ☐ Tin Plate Machines
- ☐ Veneer Dryers
- ☐ Wall Board Machines

Lincoln Engineering Company • St. Louis 20, Mo.

Please give me information on Centro-Matic Systems for (type of machine)_____. Please send me literature on Centro-Matic Systems ☐.

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*City*_____ *State*_____

ISE 846-7

NEWS SUPPLEMENT June, 1946

Equipment
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Literature

Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

EUGENE G. GRACE TELLS OF BETHLEHEM EXPANSION PROGRAM

▲ Predicting an "ever widening future" for Bethlehem Steel Corporation which will make it an "even greater factor in America's industrial life," E. G. Grace, chairman, said in his annual report to employees that 134 million dollars has already been authorized to improve facilities.

More than three-quarters of the report to employees is devoted to the corporation's impressive war production record. Ships and steel were Bethlehem's main contribution to victory in World War II, the report showed, and they were supplied in generous measure.

To carry out its war production program, the annual report to employees pointed out, facilities had to be expanded to the extent of more than 395 million dollars. Of this sum, 192 million was provided by Bethlehem and 203 million was provided by the government for facilities which the government would own.

The 134 million dollars authorized for improved facilities, Mr. Grace said, "will be extended as conditions warrant."

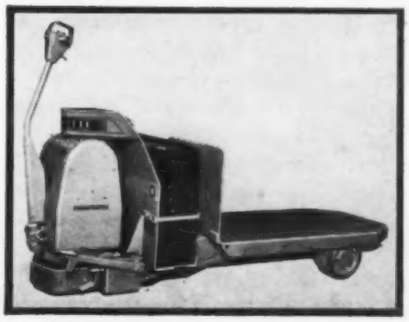
Improvements authorized include new equipment for the rolling of stainless steel bars, expansion of capacity for making steel rolls and diversification of facilities at the structural steel division here; amplification of the tool steel division here and the wire, car shop and car wheel departments at Johnstown, Pennsylvania; extension of the bolt and nut operations at Lebanon, Pennsylvania, and the wire rope facilities at Williamsport, Pennsylvania, and addition of various facilities at Steelton, Pennsylvania.

PRODUCTION IN PROCESS ON NEW ELECTRIC INDUSTRIAL TRUCK

▲ The postwar "Transporter" is here. Automatic Transportation Company, manufacturers of the "Transporter," announced production was in process on new improved models of this electric propelled hand truck whose performance has been so outstanding. Featuring more than a score of major improvements, the new electric truck will have a potential service life double that of its predecessor, and the costs of maintenance will be cut in half. The company engineers describe the new truck as a more efficient unit with added ruggedness and more effective safety features plus a simplified design that makes for greater ease in inspection, maintenance and adjustment.

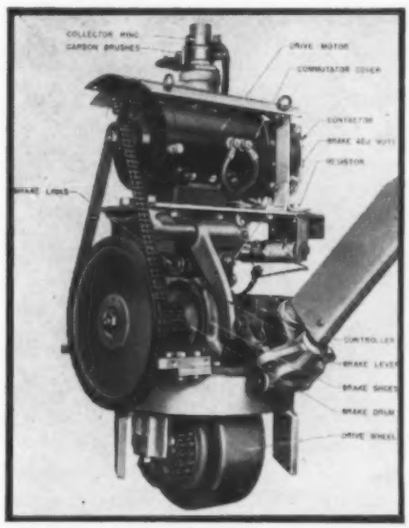
Selling price of the postwar conveying units will be the same as for similar prewar models, of which more than nine thousand are now in use in virtually every type of industry. Increased production and demand make it possible to offer all industry this improved material handling unit at no increase in selling price.

In appearance, the unit is largely unchanged. Improvements in the postwar models are designed to improve performance, increase the life, and minimize maintenance cost, which has already proved invaluable in the material handling programs of firms in the steel industry, 26 of which are already using 72 of these trucks to improve material handling efficiency and to end the back-breaking effort formerly required of workers to move loads.



More than 9000 of these electric trucks are now in use.

Structural changes in the postwar unit constitute a complete redesign of the driving unit. Principal modifications, which result in freer access for maintenance and greater durability of working parts, include a new magnetic contactor, new commutator type collector rings equipped with carbon brushes, simplified controller with reduced number of contacts, larger and stronger double-pitch reduction chains, strengthened countershaft, larger countershaft bearings to compensate for larger brake, and simplified wiring.



The driving unit has been completely redesigned to permit greater durability of working parts.

The new electric truck is being made in four models: 4000- and 6000-

A portable plug-in charging unit is available for use with these trucks.

pound capacity platform types for skid platforms; 4000-pound capacity fork type for pallet loads; and a special 3000-pound capacity fork model for tin plate.

—E-15—

ELECTRICAL CONTROL IN PRECISION GRINDING

▲ Electrical control has two outstanding characteristics which recommend it to precision grinder design. First, the comparative facility of grouping operator manipulated elements within working area reach. Second, the unlimited possibilities for adaptation of the exact circuit functions to best accomplish the desired machining operation.

In the order mentioned above, push buttons, selector switches, rheostat knobs, etc., should be convenient to the operator in his normal working posture. The button contours should be distinctly varied, permitting positive machine control without removal of the eyes from the point of wheel contact. Selector switch circuits should be so designed that an absolute minimum of positions with maximum functional flexibility are available. The combining of all selective control elements into one multi-position setup selector station deserves careful consideration. Exploitation of this latter suggestion results in the elimination of a multiplicity of switches, the correct operation of which requires a measure of operator intelligence and concentration. Application of the recently developed electrical tachometers fills a long felt need for visual indication of speeds and feeds. Being relatively small, the remote indicators of these instruments may be conveniently mounted at eye level. Water and oil proof control stations effectively eliminate personnal hazard and minimize maintenance.

Extremely adverse atmospheric conditions in the average metal plant dictate highest quality in grinding machine control. Aggravating the situation is the fact that fluid coolant is universally employed. Minimization of maintenance and long life of control is a function of contactor design and correct application engineering. The full responsibility for attainment of these two prerequisites falls on the machine tool builder. Selection of control elements and their subsequent application to the machine requires a thorough knowledge of the particular conditions involved. The builders engineering organization working in close cooperation, as a team, with engineers from the electrical manufacturers staff has demonstrated time after time that results previously unattainable could be and are practicable.

Accessibility of electrical control has recently come under serious discussion by large users of machine tools. Considerable disagreement as to what constitutes accessibility seems to be prevalent. Apparently certain factors peculiar to individual plants determine the most accessible location of control cabinets or compartments. In general, large complicated control panels should be externally mounted, whereas small relatively simple panels may be conveniently machine housed. The availability of floor space must be considered when externally mounting control.

Grinding technique requires copious power applied at the point of wheel contact. This may be accomplished readily. However, the rate at which the power is applied to the work piece presents more difficult problems, problems involving precise control of motor speeds. For example, the headstock of a grinding machine requires great versatility. Wide speed range infinitely adjustable, abundant power at all speeds, quick positive starting and stopping and inching. These requisites have been met by utilization of the variable voltage system of motor control. Two systems are in general use, i.e. the shunt wound or Ward-Leonard and the newer and simplified Landis Tool — Westinghouse series wound. Electronic variations of the Ward-Leonard system have been recently announced.

Widespread use of direct current motors for wheel spindle drives have motivated the development of control systems whereby the peripheral speed of the wheel face is maintained constant as wear progresses. Increased production, better finish and longer wheel life result.

Semi-automatic machine functions and certain full automatic cycles have been widely applied. High production of repetitive work and operator personnel problems make this type of control increasingly desirable. The list of possible "human error" eliminators is legion. To name a few: Electrical cycle programmers and timers, automatic sizing or gaging devices, automatic loading and unloading mechanisms and automatic inspection stations.

The acceptance of electronic control by industry points the way to still greater precision with increased production. Machine tool engineers are well aware of the possibilities of industrial electronics. Coincident with the decrease in demand for electronic equipment by the armed services will come a vast upsurge in industrial application. We are undoubtedly on the threshold of an atomic era.

As industry returns to competitive business, prudence suggests that you select your precision grinding equipment with an eye to the electrical control. A minimum of down time and maximum operator-machine efficiency will pay off in greater profits.

—E-16—

MOTOR GENERATOR SET FOR AUTOMATIC D-C CHARGING

▲ An automatic motor generator set for direct current charging of motorized lift truck batteries in either lead-acid or nickel-iron types, is the latest product of the Motor Generator Corporation, a division of The Hobart Brothers Company. The generator is a 15-16 volt, d-c, 50 ampere, ¾ kw diverter pole type, conservatively rated and built as an integral unit with a three-phase, a-c, 220/440 volt, 60 cycle, 1½ hp squirrel cage induction, ball bearing motor.

GENERAL ELECTRIC COMPANY DEMONSTRATES NEW MILL MOTOR LINE TO STEEL PLANT OFFICIALS

General Electric Company recently demonstrated their new line of mill motors to the A.I.S.E. mill motor committee and representatives of the steel industry who are shown, together with General Electric representatives, in the photograph at the top of this page.

The new line of motors, called the 600 line, are similar to the MD-400 motors except that the motors have been reduced one frame size, so that each present frame size offers the next larger rating. All existing A.I.S.E. ratings (horsepower, speed, temperature, and mounting dimensions) are maintained. This objective is accomplished through improved design resulting in better commutation, higher efficiency, better ventilation and equal or lower Wk^2. Although, insulation has been improved through the use of a silicone varnish binder on mica taped armature coils, higher temperatures are not used in the motors. One of the unique features of the line is the fact that the motors, because of the various removable covers, can be changed easily from enclosed to open, or a blower can be attached in a very short time.

Other features of the new line are solid roller bearings, bearings are closer coupled, larger threaded ends of shaft on the four small sizes, full complement of commutating poles, higher maximum safe speeds, savings in space and weight, and improved mica and glass insulation.

The motor is not yet in production and all frame sizes have not been made. However, a few units have already been installed in steel plants and these are being watched with much interest.

BUD SCOTT PHOT

Right center—Shown are four members of the original mill motor standardization committee who attended the demonstration. They are A. C. Cummins, general superintendent, Youngstown district, Carnegie-Illinois Steel Corporation; C. W. Lange, General Electric Company; Frank W. Cramer, electrical engineer, Carnegie-Illinois Steel Corporation; and F. O. Schnure, electrical superintendent, Sparrows Point plant, Bethlehem Steel Company.

Bottom right—I. N. Tull, electrical superintendent, Republic Steel Corporation is shown here listening to L. A. Umansky of the General Electric Company.

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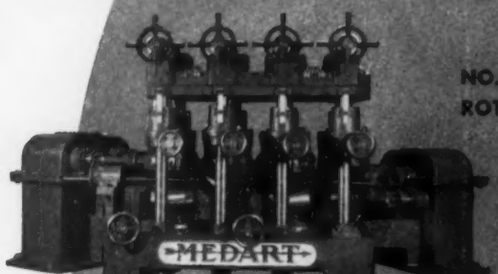

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MANUFACTURING ENGINEERS OF COMPLETE TRANSMISSION EQUIPMENT AND SPECIALIZED MACHINERY

MEDART

THE MEDART COMPANY

USE FIBER GLASS IN INSTRUMENT DIAPHRAGM

▲ Before the war, goat's skin, and only skins of goats raised in the high peaks of the Himalaya Mountains were considered sensitive and durable enough for use in diaphragms. These skins (unpunctured by mosquitos and unblemished by ticks which can't survive the rigors of the "hump's" climate) were unavailable during the war period. Research engineers of Askania Regulator Company found a solution to the shortage which proved better than the original — diaphragms of fiber glass.

Development by the Askania Regulator Company of a new highly sensitive diaphragm for control and instrumentation, can be traced directly to war time shortages. The new diaphragms are non-porous, do not sag or stretch, are impervious to gases and vapors and have high resistance to alkalis and acids. They have a much longer life than the previously used goat leather.

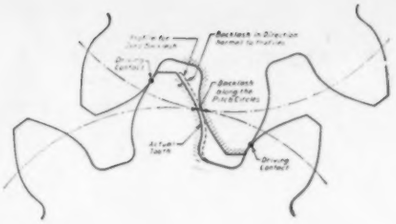
—E-18—

AGMA SETS STANDARD FOR GEAR TOLERANCE

▲ It is fortunate that at the start of the war the standardization of gear tolerances had made considerable progress, even though it had not yet become American Standard. Information on this subject in the form of tables had been made available to gear manufacturers as well as having been published in the technical press. Many newcomers in the gearing field — designers, gear manufacturers, users — had access to this information, and were able to utilize it to good advantage, either directly in its original form, or suitably modified for particular applications.

As the war progressed, the tremendous production of all kinds of gears, ranging from fine instrument gears to large ship-propulsion gears, afforded an excellent opportunity to improve and extend the project, until it was ready to propose as an American Standard.

The new American Standard on Gear Tolerances and Inspection, B6.6-1946, is made up of three parts — Section 1, Spur and Helical Gears; Section 2, Bevel and Hypoid Gears; and Section 3, Backlash in Gears. It includes gears ranging from ¾ inch



to 100 inches in diameter, and from 1 to 32 diametral pitch, with a wide choice of tolerances varying according to several speed and accuracy classifications.

The present section on backlash supersedes the American Recommended Practice on Backlash for General Purpose Spur Gearing, B6.3-1940, which applied only to spur gears. The principal change is that backlash is now specified in a plane of rotation rather than normal to the tooth profile, thus making the table of backlash applicable to other kinds of gears besides spur. The relation of these two methods of measuring backlash is shown in the accompanying illustration.

As would be expected in starting a task of this sort, all possible information was collected from publications, gear suppliers, gear users, and manufacturers of gear-cutting machines and checking instruments. It was soon evident that data from these sources, while perhaps satisfactory for certain limited gear applications, were far from being an adequate basis upon which a standard could be formulated. The British Standards covering spur, helical, and bevel gears were carefully studied, and although they contain excellent data on gearing in general, their tables of tolerances were for the most part entirely too liberal to meet the standards of gear accuracy prevailing in the United States at the time. Consequently, it was necessary to start almost from scratch to build up the present tables of gear tolerances.

When tentative tables of tolerances had been established, it was found that they were of little use until accompanying definitions, illustrations, and descriptive methods of testing were added, all of which now swell the standard into a practical treatise on the subject of gear inspection. The section on backlash, particularly, contains much new information that had never been correlated and publicized before.

One very controversial issue centered on whether to include the composite check and suitable tables of tolerances. This is an inspection method in which the gear is rolled tightly in mesh with a master, and changes in center distance observed or recorded on a chart. In the end, this test was omitted, mainly for the reason that to include it would have greatly lengthened and complicated the standard, although its value as a routine check for mass production is widely recognized. Moreover, it is only practical for gears of relatively small size in comparison with the large range of diameters covered by this standard.

When each individual section was completed in tentative form, it was given wide circulation. The many comments received were indicative of a lively interest on the part of both gear makers and users, and particularly of the need for such standards. Finally, each section became an AGMA Standard.

In spite of several years of practical application, it is not claimed that this standard is perfect. Many changes will be required from time to time as progress is made in the manufacture, inspection, and application of gearing.

Neither is it claimed nor intended that these tolerances are to form a rigid specification for gear accuracy. Rather it is emphasized that ultimate performance is the final criterion in the acceptance or rejection of gears. But when gears fail to perform properly, definite inspection methods and tolerances prove an invaluable aid in locating the cause and overcoming the difficulty. And last, but not least, the gradual trend toward manufacture of more and more gears on an interchangeable basis, and demands for quieter and smoother gears, and higher load-carrying capacity, call for maintenance of gear tolerances within ever closer limits.

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B. N. Salverson, Bethlehem Steel Company, and Harold C. Lindberg, secretary Buffalo section, are shown at the registration desk before the meeting. (Above)

BUD SCOTT PHOTO

C. J. Porter, left, one of the authors, is planning his paper with Henry Davis, chairman of the Buffalo section. (Above right)

Buffalo Section Visits CANADA

Over 400 steel mill engineers and their guests attended a dinner meeting and inspection trip held by the Buffalo section on Wednesday, May 15. The inspection trip was through the new 56 in. hot strip mill in the plant of The Steel Company of Canada, Ltd., at Hamilton, Ontario.

The dinner meeting was held after the inspection trip in the ballroom of the Royal Connaught Hotel, at Hamilton, Ontario. Two papers were given at this meeting; the first was titled, "56 in. Hot Strip Mill, The Steel Company of Canada, Ltd., Hamilton" was presented by C. J. Porter, electrical engineer, Steel Company of Canada, Ltd. The paper covered the general design and features of the equipment in the new hot strip mill. The second paper by W. J. Shortall and D. C. McCrady, of the Canadian General Electric Company, Ltd. was titled, "Special Control Features for Main Mill, Flying Shears, Tables and Coilers."

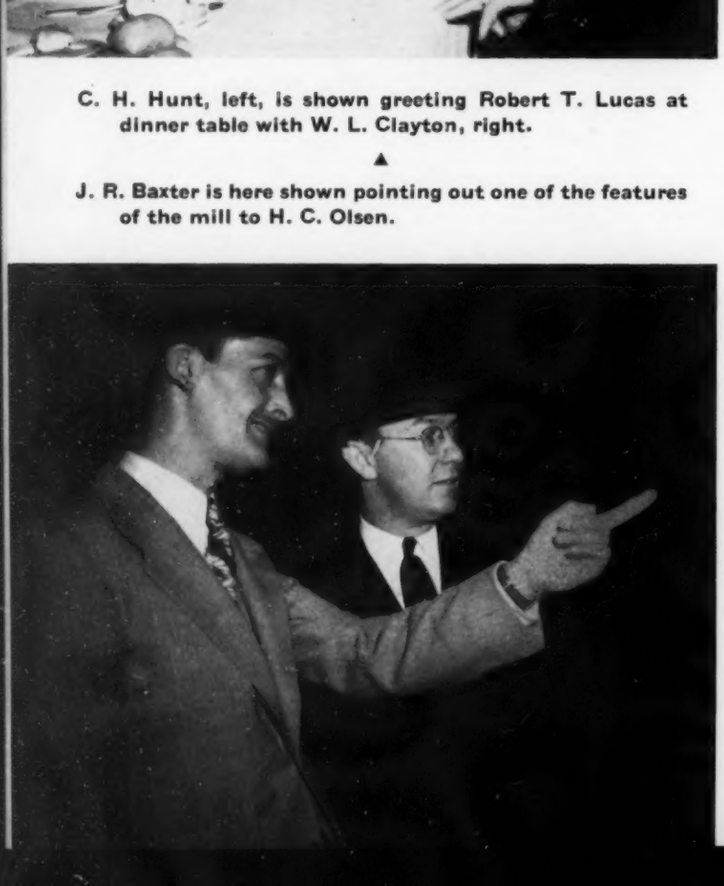
Both the meeting and the inspection trip were an unqualified success.

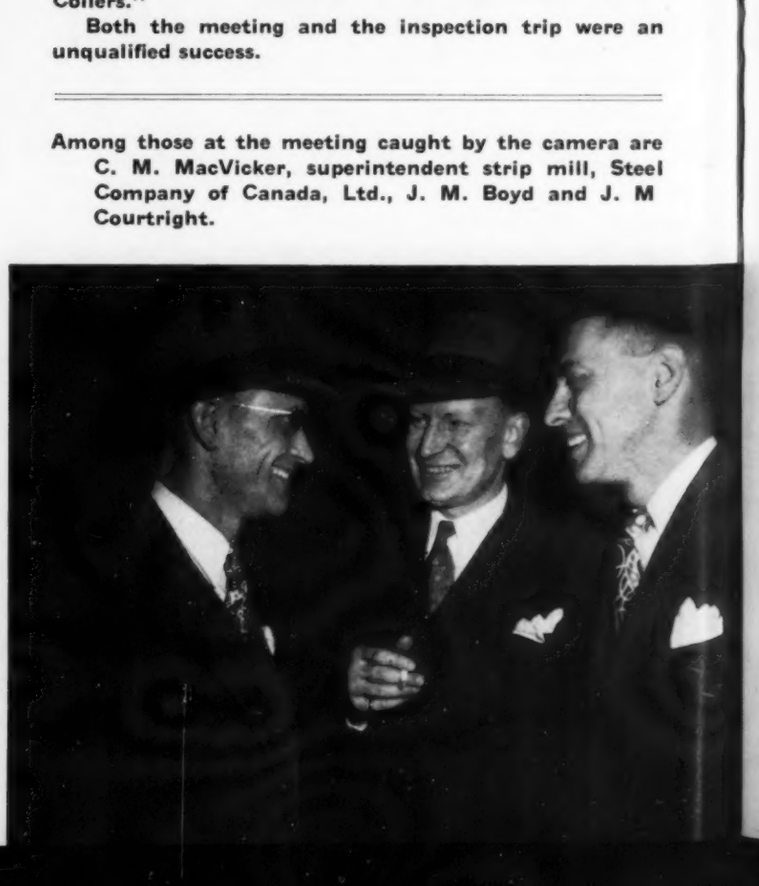
C. H. Hunt, left, is shown greeting Robert T. Lucas at dinner table with W. L. Clayton, right.

▲

J. R. Baxter is here shown pointing out one of the features of the mill to H. C. Olsen.

Among those at the meeting caught by the camera are C. M. MacVicker, superintendent strip mill, Steel Company of Canada, Ltd., J. M. Boyd and J. M Courtright.





RECORD BRITISH STEEL OUTPUT

by

S. Gordon Coller

▲ Britain's steel industry has raised the value of its exports to some 75 per cent above the 1938 level. In actual tonnage exported even the United States, greatest of steel producing nations, has been outstripped. These facts not only represent an astonishing achievement by British industrialists, workers and technicians in the midst of the immense problems of transition from a war to a peace footing, but they are also of leading importance to the rest of the world. Steel is generally regarded as the index to overall industrial production and strength of a nation, and the resilience of Britain's steel industry following World War II is therefore an unambiguous pointer to the robust health of British industry as a whole, and to the maintenance of the nation's unrivaled position as the hub of world commerce.

In the first quarter of this year, Britain sold to overseas customers steel worth £18,681,000 ($75,377,835), equivalent to an annual export rate of £74,724,000 ($301,511,340) compared with the 1938 figure of £42,791,000. On a tonnage basis the increase over 1938 is 18 per cent, but it is the financial measure which is important, since Britain's export targets are based upon the money she needs to earn to buy essential imports from abroad and make good the loss of income from overseas investments and other sources which she sacrificed during the war to save freedom. This increase, moreover, has been achieved despite the inevitable post-war handicaps of coal and high-grade iron ore shortages. More than 50 countries, covering almost all the world's surface, are pouring in orders for British steel and steel products. Among the most urgent orders being those for rehabilitation purposes from European countries such as Holland, Belgium, France and Denmark; all those nations, however, with whom the quality of British steels and the excellence of engineering involved were by-words before the war are represented, as well as many new customers attracted, perhaps, by the memory of what British steel achieved during the war in armaments from the famous 25-pounder field guns to those of Britain's latest battleships.

The sharp rise in British steel exports is not, however, the result merely of turning over a greater proportion of total output to overseas markets — Britain's home demand is itself far too great to permit of this: it is the accompaniment of a general rise in the volume of total steel production, which had reached an annual rate of 13,295,000 tons at the end of March, compared with 11,820,000 tons in 1945 and 10,398,000 tons in 1938, the last full peace-time year. With the balance of this output which, if maintained, will beat in 1946 all records in the history of the British steel industry, producers are making immense efforts to supply the rising home demand, particularly for the housing program, which includes a permanent all-steel prefabricated house. Indications are that these home demands will not be met as efficiently as the demands of overseas customers, since latest returns show that the metals and chemicals industries are those showing the greatest increase in employment of all industries engaged in re-absorbing men and women from the demobilization program. These two between them show an employment figure of 2,635,000, and this figure actually represents an increase of 599,000 compared with mid-1939. Ancillary and other civilian industries show an increase of 2,029,000 persons employed since the end of the war, a rise of 67 per cent, so that the labor bottleneck of transition production is being steadily widened, there being at the end of February a gap of only 600,000, or 10½ per cent, still to cover to reach the mid-1939 basis for civilian industries. At the same time, the numbers employed in the export industries, or export sections of other industries, has passed the 1939 figure of one million by 52,000, and show an increase of 417,000 over the end-of-war total. It is a striking tribute to the wartime increase in the efficiency of all these industries and the labor engaged in them, that the general increases in production are always higher than the increases in labor employed, showing that output per man is still rising steadily in British industry.

This news of steel output and exports gains further in significance when the recent history of the industry is recalled. During the war, the demand for high-grade steels increased enormously, since steel is the basis of strength in war as in peace, whilst the imported ores upon which British furnaces had largely relied before the war were largely cut off during the war years. The first task was, therefore, to raise Britain's home production of iron ore, which was accomplished by a 50 per cent rise from the 1935-38 average of 12,417,000 tons to the 1942 output of 19,504,000 tons.

Simultaneously, scrap saved for steel making was raised by nation-wide efforts from the (estimated) pre-war average of 5,800,000 tons to 7,782,000 tons by 1943. With coal, the basis of all British heavy industry, the raw materials were thus provided by common efforts, although they often yielded a lower return per ton and thus put a brake on output. Nevertheless, the output of steel ingots and castings was raised from the pre-war average of 11,256,000 tons to no less than 13,031,000 tons by 1943. The next difficulty was the fact that the demand for alloy steels grew heavily, and thus made a continuously greater claim on available man-hours — yet, in addition to an overall increase in production, the output of alloy steels was raised no less than 300 per cent. Some of these difficulties are still with the industry, supplemented by the strain of six years' all-out effort on labor and plant, so that the recent further increase in output to record proportions is a particularly fine achievement.

Similarly, in the case of exports, the British steel industry has achieved its new record in the face of immense handicaps suffered during and since the war. Britain's exports of iron and steel manufactures were reduced, during the turnover to war production of all available resources, from the already low 1938 level of 1,915,000 tons to the mere trickle of 134,000 tons in 1943, so that many overseas customers of British firms had to turn to other suppliers. Yet latest returns show that these buyers had long memories for the quality of British steel products, and it is to this factor and to its own superhuman efforts that the steel industry owes its triumph over difficulties and its victory in the export race. And to one further factor — the rapid and continuous technical progress of the in-

dustry, which has been greater during the war than at any time since Sir Henry Bessemer, S. G. Thomas, P. C. Gilchrist and others established British leadership in steel for the first time.

NEW SPHERICAL BEARING CARRIES HEAVIER LOAD

▲ Development of a new type of roller bearing capable of carrying heavier loads at higher speeds and lower temperatures, heretofore a "missing link" in the chain of antifriction bearing evolution, was announced by SKF Industries, Inc.

The new development, technically known as a spherical roller thrust bearing, climaxes a 10-year research program to solve the difficult problem of combining in a single bearing the triple feature of high-load capacity, speed and low temperature. Heretofore, this triple combination of bearing principles has been a prime engineering and research puzzle.

Applications of the new development are as thrust blocks on roll necks in steel and aluminum rolling mills, and as thrust mountings for railroad turntables, water turbines, water wheels, oil well swivels, dredge pumps, extrusion machinery for plastics and rubber, and various types of gear drives.

The bearing's self-aligning principle which compensates for any shaft deflections, distortions or weaves, permits heavy loads to be distributed evenly over all rollers and eliminates danger of overloading. Because of its compactness, it utilizes less space and is lighter in weight than a plain bearing. SKF production facilities have been tooled to develop preferred sizes for immediate manufacture.

—E-19—

THERMAL DELAY RELAY FOR LARGE CURRENTS

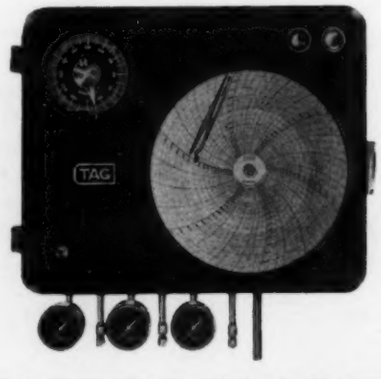
▲ The instrument division of Thomas A. Edison, Inc., announces the "Model 501" thermal delay relay. This relay provides manufacturers of electronic and electric equipment with a thoroughly reliable means of delaying the control of heavy current circuits for a predetermined time interval, and also for eliminating chatter from delicate instrument contacts. Designed for continuous operation with its heater energized, the relay combines both time delay and control functions in one unit with no danger of false operation caused by heat from the heater affecting the ambient temperature compensation. Thus the need for an auxiliary lock-in relay to cut out the heater after it has performed its function or to handle the lead current, is eliminated. This relay offers a high ratio of controlled to controlling power and permanently accurate timing, with preset delay periods obtainable from 2 seconds to 8 minutes.

Basically the relay consists of a heater coil wound around a bimetal strip supporting the moving contact. The fixed contact is supported on a similar bimetal strip to maintain the same contact separation, and hence the same delay period, under widely varying ambient temperatures. Thermal insulation between the two bimetals confines the effect of the heater to the moving contact bimetal, thereby eliminating the danger of premature contact opening due to heat transfer from the heater to the ambient compensating bimetal.

—E-20—

PUSH BUTTON CONTROLS PROCESSING COMPLETELY

▲ A fully automatic recorder-controller for temperature and pressure has been announced by the C. J. Tagliabue Division of Portable Products Corporation. This instrument, a notable addition to an extensive line of indicating, recording and controlling instruments, requires only the push of a button to control processing completely from start to finish. By use of an adjustable cam, timing starts automatically when the temperature reaches the processing point and is terminated at precisely the desired moment. All valves, whether steam, air, water or overflow, are opened and closed as the process may require without manual attention of any kind.



This instrument requires only the push of a button to control processing completely from start to finish.

A red light glows on the controller during the entire steam-heating phase of the process. When heating has been completed and steam has been shut off, the red light is extinguished and a white light appears. After sufficient time for cooling has elapsed, the white light goes out, indicating visibly to the operator that this cycle has been completed.

This unusually efficient instrument, its entire mechanism housed in a compact, relatively small case, is adaptable to many processes involving the control of temperature and pressure in the manufacture of rubber, plastics, chemicals and textiles.

—E-22—

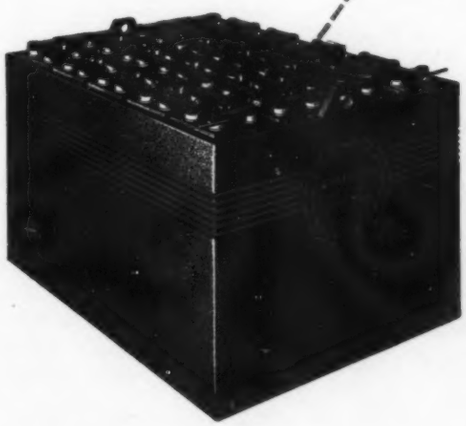
BLOWPIPE CUTS STEEL FASTER AND EASIER

Cutting through 24 in. of steel is an easy job for this man-sized Oxweld type C-45 blowpipe — the world's largest. The blowpipe, manufactured by Linde Air Products Company, is cutting up the hot-top ends of a partially forged ingot of chrome-nickel-molybdenum steel, 24 in. thick, at a speed of 3 in. per minute. The use of this oxy-acetylene method for cutting hot-dip scrap into charging box size has resulted in savings of 50 per cent over the previous method.

—E-21—

New ways to save with PHILCO BATTERIES

Now you have palletized unit loads, and the new long-life Philco "Thirty" motive power batteries to make modern electric trucks even more useful and economical. The 30% longer life of Philco "Thirty" means substantial savings in battery replacements. Ask for Philco "Thirty" as initial equipment in your new trucks. Specify Philco "Thirty" on battery replacement orders. Write for specification data today. PHILCO CORPORATION, Storage Battery Division, Trenton 7, New Jersey.



PHILCO

FOR 50 YEARS A LEADER IN INDUSTRIAL STORAGE BATTERY DEVELOPMENT

ELECTRONIC PYROMETER HAS NO MOVING PARTS

▲ A new electronic potentiometer-pyrometer which has no continuously moving or vibrating parts in its measuring circuit is announced by Bailey Meter Company. It records one or two temperatures on a 12 in. diameter uniformly graduated chart and indicates on a 29 in. bold scale which encircles the recording chart.

This indicating, recording and controlling instrument requires a 115 volt, 60 or 50 cycle, a-c power supply. It operates from a thermocouple or from any source of d-c potential which varies through at least 10 millivolts for full scale range. Conventional thermocouples are used for temperatures up to 3000 F. For temperatures above 3000 F and for moving objects above 1500 F radiation type thermocouples are used.

The d-c potential of the thermocouple or other primary element is balanced against a conventional potentiometer circuit employing the usual battery source of d-c voltage and a standard cell with manual standardization. Instead of a galvanometer or millivoltmeter the "Pyrotron" potentiometer circuit employs a d-c to a-c converter and an electronic detector, to measure potentiometer unbalance.

Trouble-free service and a minimum of maintenance are insured by the elimination of galvanometers, millivoltmeters and all continuously moving or vibrating mechanisms from the measuring system. Only the recording chart moves continuously. The reversible electric motor which drives the indicating, recording, and controlling features moves only when the potentiometer network tends to become unbalanced because of a change in the factor being measured. Conversion of d-c potential to a-c is accomplished by special saturable core reactors which are similar in construction to transformers in that they contain no moving or vibrating parts.

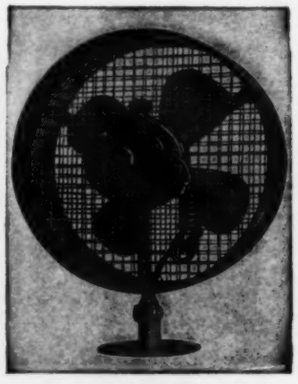
This instrument is said to be an effective controller for temperature since its inertia free electronic detection and high speed motor system instantly respond to keep the measuring circuit in continuous balance. Its accuracy, stability and permanence of calibration are credited to the use of the null balance principle.

The pyrometer may be furnished with two controllers operating from two entirely separate measuring circuits all housed in the same recorder casing. This arrangement permits double the number of recorder controllers to be included in a given panel space.

The recorder-controllers are furnished for air-operated control systems, on-off electric control systems and throttling type electronic control systems. The instrument illustrated is cut away to show its control dial by which the set point may be manually adjusted to any desired temperature. This arrangement is used for the on-off electric and throttling electronic type controls. Air-operated control systems are provided with an indicating pointer which uses the recording chart as a scale for indication of the set point. The set point may be changed by simply opening the meter door and turning a convenient knob.

—E-23—

IS HEAT SLOWING UP YOUR WORKMEN?



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(1) Handy Data Book

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(2) Power Shears

A really new shear is described in a catalog available to you. The catalog describes the cutting principle which is entirely different from any other shear now on the market. The shear has features never before available, such as: the new pivoted-blade cutting principle; tight-clamping mechanical hold-downs; trouble-free efficient drive; quick change from squaring to slitting position; knives stay sharper longer; and heavy spring counterbalances. The booklet also gives clearance dimensions and specifications. (2011-A) The Cleveland Crane and Engineering Company.

(3) Bearing Maintenance

Never attempt to mount a bearing on a shaft that has not been wiped clean and given a light coat of oil. Dirt or chips could be trapped between bearing and shaft shoulder, preventing complete or accurate seating. If you would like additional practical hints on getting the maximum life from ball bearings, they can be found in "Service Procedure for Ball Bearings." This book is available to those persons interested in the maintenance and servicing of bearings, as well as those who are interested in shorter shut-down periods. (SP). New Departure.

(4) Dust Recovery Systems

"Advances of Buell (van Tongeren) Cyclones in Industrial Dust Recovery Systems" is the title of a bulletin available to operating executives and engineers. The bulletin diagrams and describes three methods of dust distribution in mechanical collectors and what happens when uniform distribution does not take place. The booklet is an engineering guide for the selection of the right dust collection equipment. Buell Engineering Company, Inc.

(5) Pipe Cleaning

A reprint of an article which appeared in a recent IRON AND STEEL ENGINEER is available to you. The article is entitled "Pipe Cleaning," and discusses the cleaning of pipe in the following classifications: Blast furnace hearth jacket cooling pipe; boiler tube cleaning; new pipe cleaning; condenser or heat exchanger tube cleaning; chemical lines; water lines; sewers and drain lines; and gas lines. All maintenance supervisory personnel concerned with the cleaning of pipe should have this article for their file. Pittsburgh Pipe Cleaner Company.

(6) Temperature Control . . . . Electronically

Details on an unusual electronic resistance thermometer are included in a new catalog which is yours for the asking. The bulletin describes air operated systems; on-off electrical systems; and modulated electronic systems. Discussed is the new "Pyrotron" which resists vibration and shock and needs no careful leveling; the motor drive provides abundant power for operation of recording pen, controller, alarms and signals; simple a-c measuring bridge needs no battery; sturdy electronic units keep the bridge in continuous balance and replace the usual galvometer with its attendant mechanism for step by step balancing; interchangeability of packaged units simplifies replacement. (230-A). Bailey Meter Company.

(7) Refractory Concrete

A new edition of "Lumnite for Refractory Concrete" has just been published. This booklet contains basic information on materials and methods used in making refractory concrete for different temperature and insulating requirements. Illustrations show a wide range of applications of refractory concrete in the construction of heat-treating furnaces, cooling pits, coke ovens and ceramic kilns. A section of the booklet is devoted to heat-resistant concrete for foundations, floors and structures subject to soaking heat. Information in the new edition reflects the results of service experience and laboratory investigations since publication of the original booklet on this subject in 1938. The Atlas Lumnite Cement Company.

(8) Material-Handling Handbook

If you want action-stirring ideas for important savings from an unsuspected source . . . mechanized material handling with electric industrial trucks, you can obtain them from a new material-handling handbook that is available to you. This guide offers practical how-to-do-it suggestions for raising machine-hour and man-hour productivity and reducing floor space requirements for a given production volume. The principles of industrial trucking are described in detail and illustrated in use. Even if your present handling system is mechanized, you will discover in this manual new suggestions for immediate savings thus far overlooked. (54 pages). The Electric Industrial Truck Association

(9) Goggle Cleaning

A new bulletin, featuring a goggle cleaning cabinet with "Fogpruf" for installation in all parts of the steel mill where goggles are used, is obtainable. The folder describes how this new material encourages workers to wear their goggles and to keep them clean. Adapted for convenient wall mounting, the cabinet is equipped with an efficient lens cleaning and anti-fogging agent, and optical wiping tissues. (CE-28). Mines Safety Appliances Company.

(10) Renewable Fuses

Fuses are such little things that we often pass over them without thinking of the importance they hold in the production flow. Needless fuse blowing causes delays, production interruptions and costly material wastage. There is available to you a catalog on "Hi-Lag" renewable fuses that give a higher lag for motor starting overloads, stronger lag for operating current surges, larger and stronger terminal connections, lower contact resistance, all reducing heating. The catalog has an exploded view of a knife-blade assembly fuse; a description of the construction; details on the renewal links; specifications, sizes and prices, and charts on blowing time of these fuses. Ware Brothers.

(11) Indicators and Controllers

If your operation involves control of temperature or pressure you should have this catalog on controllers. The catalog describes the three basic type of controllers: High sensitivity (on-off); full range throttling; and full range throttling with automatic reset. Each type is designed especially for a particular job, and will do that job with the utmost efficiency. (1200). C. J. Tagliabue Division of Portable Products Corporation.

(12) Electrical Material

A complete catalog covering contact rail material which provides constant contact that insures reliable transmission of power to your cranes, conveyors and other electrical hoisting and hauling systems. The booklet describes a complete line utilizing either rails, angles or wire as conductors and including numerous types of insulators for either under-running or over-running operation. These products are widely used in most steel mills and have been thoroughly proved in service. Electric Service Manufacturing Company.

(13) Power Cable

From blast furnace to run-out tables, steel mills call for a temperature conscious choice of cable. The full story of the types, sizes and performances is given in bulletins available to you covering all types of cables. There is a cable, for example, for spots where high ambient temperatures are continuous, such as around furnaces, kilns, and soaking pits. Other types of cables give protection against emergency temperature rises, offering low-cost assurance against shutdowns, fires, and frequent replacement. (Y-562-31). Appliance and Merchandise Department, General Electric Company.

(14) Crane Gears

Flame hardened crane gears are described in a new bulletin which is yours if you send us the postcard below. The bulletin tells how the strength and hardness of "Neloy" steel castings for crane gears result from a combination of alloying and special hardening. The desired hardness, together with increased strength for specified requirements, result from careful metallurgical control. These castings meet with outstanding success because they are giving excellent service in many varied applications: on overhead traveling cranes, in rolling mills and steel works equipment, and other machinery. (7). National-Erie Corporation.

(15) Oil Immersed Controls

Complete information is contained in a bulletin on reduction of installation costs and space requirements for across-the-line

motor starting equipment by use of an oil immersed combination motor starter. The bulletin describes the unit which consists of sealed-off terminal compartment, disconnect switch, air seal fuses, magnetic contactor and magnetic overload relays. The overload relays are a combination of inverse time element and instantaneous operation. They are individually calibrated for 110 to 175 per cent operation. Enclosure is mechanically interlocked to prevent lowering of tank when switch is in "on" position or closing of switch when tank is lowered. (780-KBF). Rowan Controller Company.

(16) Cutoff Machines

A booklet is available discussing the variety of sections you can cut at speeds up to 200 ft per min with "flying cut-offs." Angles, tees, simple channels or intricate mouldings or conduit, all are cut cleanly and accurately with steel dies mounted on a movable table. Included is a description on how to use the cut-off machine in team with roll forming machines producing sections from strip stock. The equipment is also used to straighten or cut tubing, wire or rod, or fitted with dies or punches for perforating or embossing. Other items of equipment such as roll forming equipment, rotary gang slitters side trimmers, tube and pipe mills, recoilers, uncoilers, coil boxes and special metal forming machinery are included. Also illustrated are bending and edging machines and plate levelers. (G-451). Yoder Company.

(17) Continuous Desiccation

In a new color catalog continuous (dynamic) desiccation of gases (also liquids), by adsorption in activated aluminum and/or silica systems, is described. The catalog covers both standard and built-to-order units of capacity from 1 to 20,000 cfm handling pressures from atmospheric to 2500 psi and producing dew points as low as minus 60 F. Types of units described include manual, semi-automatic and fully automatic designs, and models in which reactivation of gel is by steam, electricity or gas-consumption. Particularly emphasized are units for use in desiccating compressed air for instrument and tool usage in the steel plant. Theory of dryer size-selection is covered and overall cost estimates for different classes of operation are given. (25-D, 48 pages). C. M. Kemp Manufacturing Company.

(18) Handling of Materials

Arranged to fit in your file for ready reference is a large catalog which covers every conceivable method of handling materials. If you are interested in the movement of your product at lowered cost through your plant we suggest that you send for this book. Complete details are given under the following classifications: cranes, floormasters, hand trucks, jacks, labor savers, lift trucks, pallets, power fork trucks, skid platforms, stackers, storage racks, and wheels. Included are charts, illustrations, dimensional diagrams on all material handling equipment manufactured by this concern. (22, 80 pages). Lewis-Shepard Products, Inc.

(19) Bearing Engineer

The "Bearing Engineer" is the title of a bi-monthly publication which will regularly come to your office with data on bearings. This little magazine, gives technical data written and prepared in an interesting manner. In the current issue appear articles on "The Saco-Lowell Needle Bearing Spindle;" "Thrust Bearing for Steel Mill Charging Crane;" "The Spherical Roller Bearing;" and many other bearing articles. (Bearing Engineer). Torrington Company.

(20) Displacement Meter

The new positive displacement meter, piston-type, called the "Transometer" for measurement and control of fuel oil is described in a bulletin designed for you. The bulletin tells how you can accurately indicate, record, integrate and control flow, flow rate, fuel–air ratio, total heat input, and summarizing of multiple fuels. The meter is built to take it and all parts in contact with the abrasive-containing fuel are quickly replaceable in the field and original calibration is maintained. (111). Askania Regulator Company.

(21) Motor Generators

The following new catalogs are waiting for you (1) Motor generators for electrolytic processes; (2) Battery chargers for materials handling systems; (3) Battery-charging equipment for motorized lift trucks. These catalogs are highly descriptive with illustrations on all of the designs of motor generators and battery chargers available. The second item is a handbook which will fit your file for easy reference. This handbook describes in detail the various types of battery chargers available and their application possibilities. We recommend the possession of these bulletins. (202, 203, 205, 206, 44 pages). The Electric Products Company.

(22) Data Card

You can have a pocket-sized data card covering use and application of wire rope clips. The card is an instruction chart giving exact number of units to be used in relation to rope size. Other data, showing application of clips and information concerning safety, is included. The clips are made of galvanized drop forged steel. American Hoist and Derrick Company

(23) Pump Valve Units

Wherever reciprocating pumps are used a need will be found for the bulletin that is available to you on metal pump valve units. These units are furnished as standard equipment supplied by the pump manufacturer and sometimes as replacement units on a wide variety of pumps. The units are used in virtually every conceivable pump application; under extremes of high or low temperature; with highly corrosive fluids; in any position; and in service where long-term freedom from routine inspection and replacement is necessary. Durabla Manufacturing Company.

(24) Steel Mill Bearings

For more efficient steel production you should read the bulletin on "A-B-K" laminated plastic roll neck and slipper bearings. The bulletin includes installation photographs and descriptions of operation. A diagram is included which shows the design for rolling mill bearing assembly. The reasons are told why reinforced edge slipper bearings do the job you may have for them to do. Also included in the bulletin is the slipper bearing problem and how this firm meets and solves the problem, thus reducing coupling maintenance and safeguarding against breakage. You will take a long step toward reducing your maintenance costs by asking us for this bulletin. American Brakeblok Division of American Brake Shoe Company.

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FOR THOSE WHO MUST *KNOW*

Products and Developments

(25) Heating Furnaces

Bi-monthly circulars, which are quite different from the ordinary, are available to you. These circulars cover the different operations of an engineering corporation set up to do consulting, contracting, designing and building. In the current circulars appear an article entitled "Sound Design Results in Heating Furnace Economies" by a combustion engineer, and another article titled: "Overfired Pit-Type Ingot Furnaces Increase Tonnage" by a staff engineer. The data in these two circulars will be of particular interest to all engineers and operating executives concerned with heating operations. Loftus Engineering Corporation.

(26) Continuous Filtration

You can remove grit and dirt 15 times finer than $\frac{1}{10}$ in. from river water, according to a new bulletin describing an automatic water filter designed to provide continuous filtration with automatic backwashing of solids to the sewer. Discussed in this bulletin is the "Poro-screen" filter which offers a practical answer to large-scale filtration of dirty river water for use in hydraulic equipment. The design is also covered and it tells how these filters supply the required volume of clean water for your operations . . . water free of dirt and grit which damage bearings, rolls, valves and other equipment. This filter has been highly successful on water cooling installations of open hearth and heat-treating furnaces. Also included is a description of the "Porostone" filter (901). R. P. Adams Company, Inc.

(27) Fork Trucks

An up-to-the-minute news picture magazine is yours if you want it. This magazine shows how wide-awake management is utilizing palletized unit loads and fork trucks to end the burden of costly manual methods and speed production. The name of this magazine is "Material Handling News," and it will periodically arrive on your desk if you circle Number 30 below. Clark Tructractor Division of Clark Equipment Company.

(28) Motor Starters

Just released is a new bulletin on motor starters which give complete protection for men, motors and equipment. The bulletin tells how the starter provides short circuit protection with high capacity disconnecting-type power fuses, heavy duty, oil-immersed contactors, accurate motor overload protection, safety door interlock, segregated high voltage compartment and factory-assembled enclosures. Also included is a description of the contactors used in the starter. These contactors have rolling-wiping action contacts, built-in multi-stage auxiliary switch, self-aligning, clapper-type magnet with novel universal joint and permanent windlass tank-lifter with removable hand crank, all of which add up to trouble-free operation and easy maintenance. (14B6410). Allis-Chalmers Manufacturing Company.

(29) Safety Stamps

A new bulletin is available that illustrates and describes a safety wedge grip letter and figure stamp, multiple character stamps for straight line, curved line, concave and convex marking, and interchangeable steel type holders for use where fast changing of characters is required. The bulletin tells how the safety steel eliminates mushrooming and spalling. The knurling on sides of stamps and holders which is known as the wedge grip feature assures positive grip during stamping operation regardless of workman's greasy fingers or greasy stamps. (WG-462) M. E. Cunningham Company.

(30) Turbine Pumps

Vertical turbine pumps are discussed in a handy file folder which is yours when you send us the postal card below. These pumps are made in a complete range of sizes and capacities from 15 gallons per minute up. They are provided with either oil or water lubrication and drive heads for any type of driver. Also described in this folder are horizontal centrifugal pumps for diversified services. Complete illustrative data on 59 separate pumps is included. (B-136). Peerless Pump Division, Food Machinery Corporation.

(31) Combustion Air

Maximum efficiency in the supply of combustion air is described in a bulletin available to you. The bulletin tells how to supply air properly to blast furnace stoves, open hearth furnaces, reheat furnaces, and boilers. The information contained in this booklet represents years of engineering study to find methods of supplying air more efficiently. (3203). Robinson Ventilating Company.

(32) Power Handling

A pocket catalog illustrating a complete line of power handling equipment is yours for the asking. The catalog includes the experience of 35 years of designing manufacturing and installation of materials handling equipment. The company that prepared this catalog is a pioneer in this field. (201-6). Mercury Manufacturing Company.

(33) Equipment News

. . . . is the name of a periodical prepared for the busy steel mill engineer or operating executive. It is complete and put together in an interesting and informative manner. Sample news items are "Hydraulic Push Bench for Sizing;" "Rolling Mills for Precision Finishing;" "Advanced Design Features Protect Precision in Roll Grinders." (20-M-461). Farrel-Birmingham Company, Inc.

(34) Push-Pull Power

"Amazing Push and Pull Power" is the title of a new bulletin issued by a manufacturer of electric propelled material handling equipment. The booklet illustrates uses and specifications of the new "Transtractor," which is a new push-pull type unit combining the features of the electric propelled hand truck and the conventional warehouse tractor. This truck will tow or push a maximum load of 6,000 pounds continuously or 20,000 pounds intermittently with finger-tip control. Complete data concerning its construction, drive unit, motor, braking system, drive control and steering mechanism is included in the new bulletin. Automatic Transportation Company.

(35) Engineering data

"Conversion Factors and Formulas for Electrical Engineers" is the title of a booklet that has been made available to engineers. It contains over 600 conversion factors commonly used by steel mill engineers, as well as definitions of basic electrical units, prefixes, mensuration and temperature conversion factors. The lists are arranged for use in a loose-leaf binder or for desk or wall mounting. The factor tables have been lacquered to add durability. Conveniently indexed, a wealth of electrical information is made instantly available. I-T-E Circuit Breaker Company.

(36) Strength Calculator

A gear tooth strength calculator is available to you for the computation of gear stresses for gears of 3 pitch to 28 pitch. This handy calculator will help you in designing gears, or in your everyday work with gears. Barber-Colman Company.

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There are 9 good reasons why you should wire circuits that are exposed to severe operating conditions with Rockbestos A.V.C. wires, cables and cords . . . and they all combine to *insure* you against failures and practically eliminate expensive circuit maintenance.

You won't have to pull out and replace power, control and lighting circuits that are failing too often . . . and then do the same thing all over again . . . if you rewire with *asbestos insulated* Rockbestos A.V.C. Its felted asbestos walls, impregnated with heat, flame and moisture resisting compounds, are built to give you the *extra* protection needed to withstand conditions that ruin wire. They make an installation *permanent*, protect circuit operation and save the cost of repeated replacement.

These *permanently insulated* money-saving wires, cables and cords are made in a wide variety of constructions for 300 to 5000 volt service . . . in sizes No. 18 AWG to 2,000,000 CM. For complete data write for a catalog.

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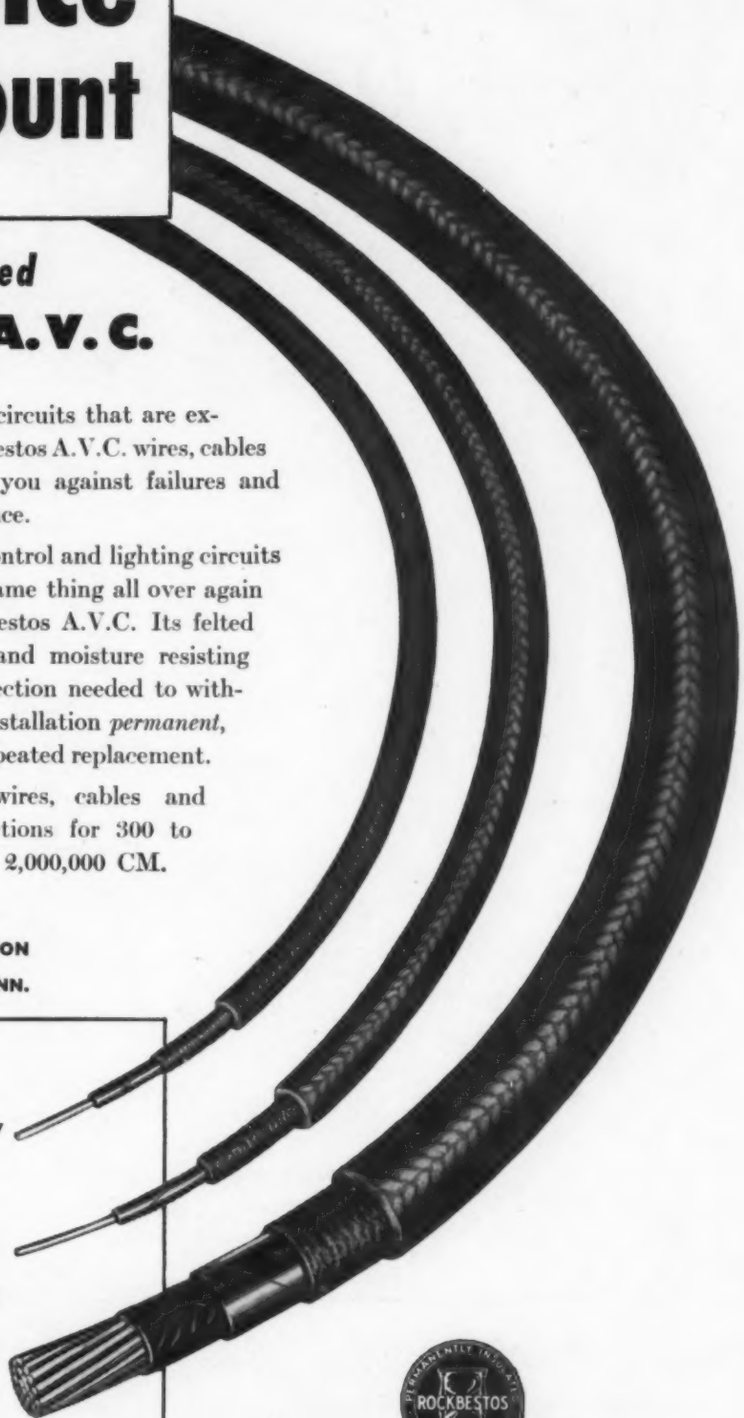

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These characteristics are built into 125 Rockbestos constructions including the wires illustrated:

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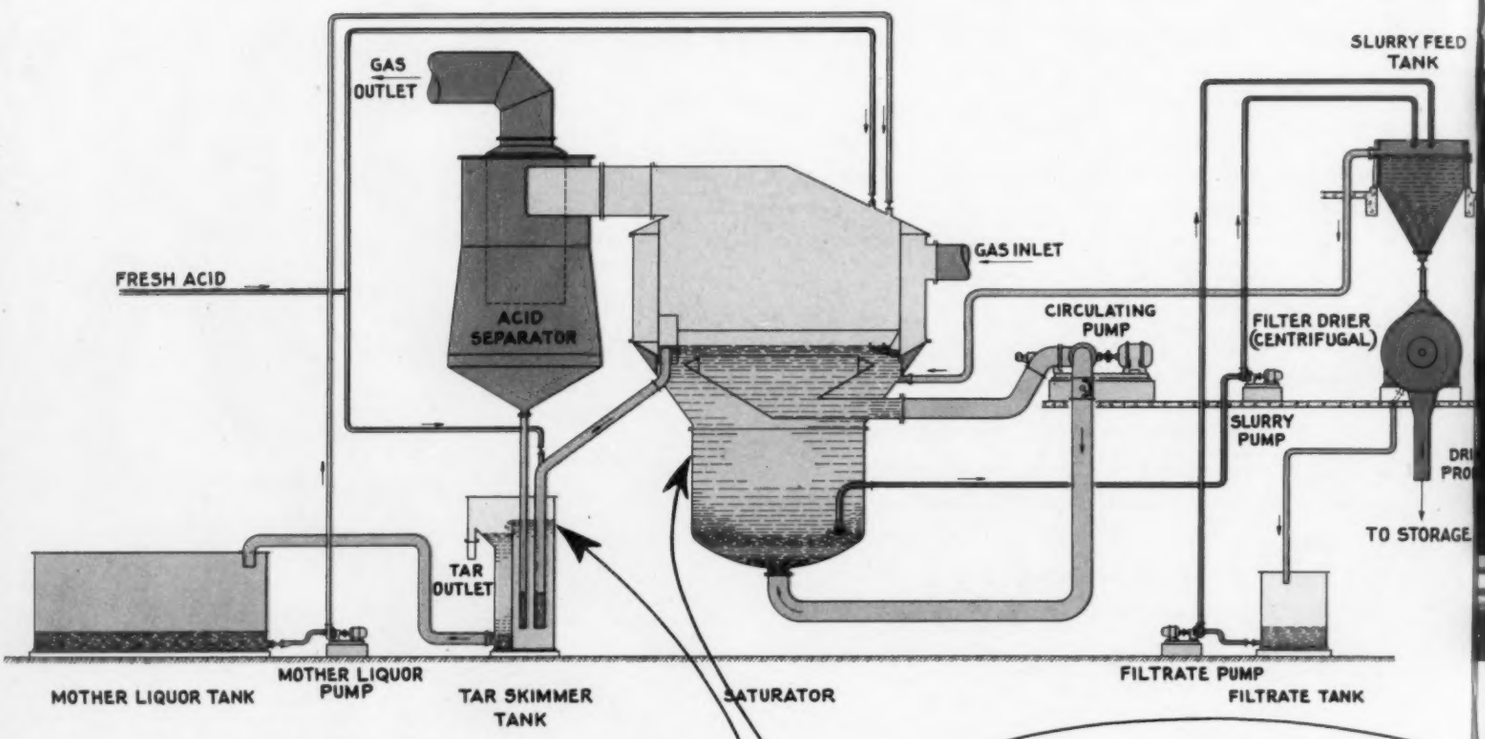

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Crystal Size is Controlled and a Uniformly Sized Salt is Produced

Single Units handling 50,000,000 Cubic Fe Co
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FOR PRODUCTION OF BY-PRODUCT AMMONIUM SULPHATE

Operations are Simplified by Planned Location of Pumps, Dryers Meters, Gauges and Titration Table for Convenience of the Operator

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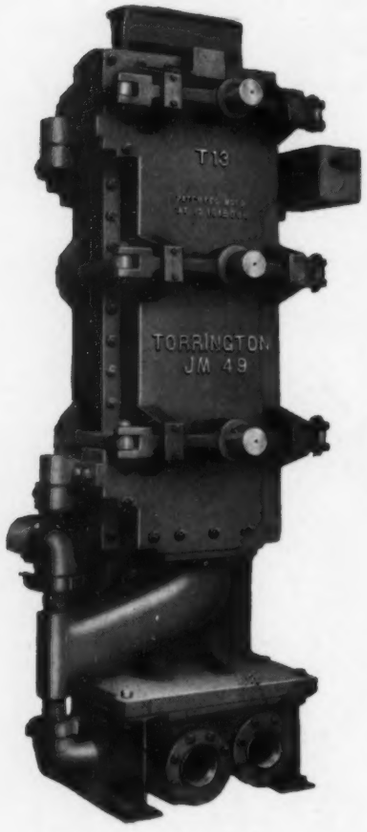


(Patents Pending)

WATER-COOLED MOLDS
FOR COPPER-BEARING ALLOYS
SPEED PRODUCTION . . . CUT COSTS

The Torrington Manufacturing Company's water-cooled molds cool in a few minutes as against the 1 to 4 hours required by air-cooled molds. Also, the life of the molds is enormously extended. Air-cooled molds usually last for only a few hundred slabs, rarely as many as 3,000. Torrington water-cooled molds average between 14,000 and 25,000 slabs per mold—up to 20,000,000 pounds—before replacement of either copper faceplate becomes necessary. And replacement plates are relatively inexpensive, due to salvage of the worn-out plate. Mold cost per pound of metal is infinitesimal, since replacement of the faceplates is usually the only maintenance expense.

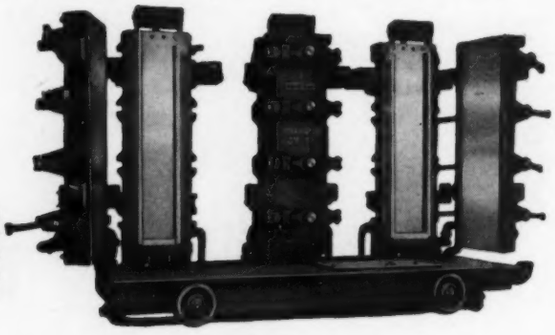
CASE HISTORY

One of the largest producers of brass used 32 Torrington water-cooled molds through 3½ war years. 21 of the original 64 plates are still usable. The number of 1,400-pound slabs cast against each plate ranged from 14,511 to 24,362. A clamp-type plate having no bolt holes on the sides was used for a total of 28,993 heats.

SPECIFICATIONS

Water-cooled molds can be built to any size or specification, and will cast any of the copper-bearing alloys. They are scientifically designed so that the water flow cools all parts of the plate evenly. Clamp type plates, with a minimum of bolts, reduce breakage by permitting expansion and contraction.

Torrington builds any type (water- or air-cooled) slab or billet molds for copper-bearing alloys.



Two or three molds on one truck, when casting smaller bars, enables full discharge of furnace. The truck makes possible quick, easy movement between furnaces, for full utilization of mold capacity.

For over 60 years, Torrington Manufacturing has been designing and building special machinery for processing sheet, strip, flat wire, rods and tubes, as well as air-cooled or water-cooled molds for casting copper-bearing alloys. Fine modern facilities include a highly trained design and engineering staff, pattern shop, forge shop, hardening room, welding shop, completely equipped machine shop, and large assembly floor covered by cranes. Experienced, skillful men work under ideal conditions. Our standard designs can be modified to meet special requirements and we work closely with customers' engineers in adapting machines or designing and building new machines. This collaboration assures special attention to maintenance and production problems. Privacy is guaranteed when we build from customers' drawings or design and build under their supervision. Materials and workmanship are also guaranteed.

Call or write Torrington Manufacturing with complete details of your requirements. We'll not only build a machine to suit your specifications, but will also help set it up and start it in production in your plant.

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MAXIMUM OPERATING TEMPERATURE

90 C — Type AVB Power Cable (600 volts)

105 C — Limit for Class A (organic) insulating materials — AIEE

110 C — Type AVA Power Cable (600 volts)

125 C — Type AI Power Cable (600 volts)

where TEMPERATURES are on the

HIGH SIDE..

150 C — Recommended limit, Cu Conductors

200 C — AA Asbestos-ASB braid (300 volts)

204 C — GV Glass-Silicone Impregnated

there's a Deltabeston Cable built to beat the heat*

Wherever wiring must withstand high temperature, you'll find that it pays to check the complete Deltabeston line of heat-resisting wires and cables.

There's a Deltabeston cable to meet the conditions normally encountered around furnaces, soaking pits, and hot strip mills. Other types are built specifically for boiler-room applications, and for jobs that must combine heat resistance with moisture resistance.

From the Deltabeston catalog, you can choose wire or cable for use in or out of conduit, with the degree of flexibility that the installation requires. If your conditions are highly unusual, specialists in the field of heat-resisting cable are "on call" to find the best solution to your problem.

*Trade-mark Reg. U.S. Pat. Off.

For your copy of the Deltabeston catalog, showing the full line of types available for each temperature and voltage range, write Section Y661-31, Appliance and Merchandise Department, General Electric Company, Bridgeport, Conn. All Deltabeston Wires and Cables are distributed nationally by G-E Merchandise Distributors.

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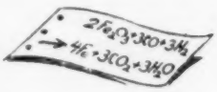
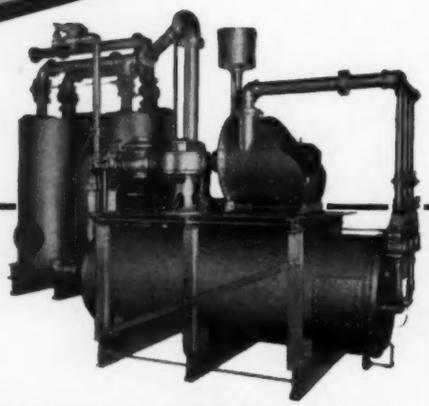
REDUCING VARIOUS METALLIC OXIDE POWDERS



TREATING SPRING STEEL IN DRY NON-DECARBURIZING GAS

THEN

KEMP "atmos-gas" fits



AT ONE OF OHIO'S LARGEST STEEL MILLS

. . . this KEMP "atmos-gas" producer guards low-carbon steel from the effects of both oxygen and water vapor—throughout a full 72-hr. bright-annealing cycle. It supplies enough protective atmosphere (15,000 cu. ft. per hr.) to keep up with 15 or 20 sheet-annealing bases. Operating at 6:1 air-gas ratio, and equipped with generous silica gel desiccating towers (left rear), it produces the analysis: N_2—72%, CO_2—5.8%, H_2—12.1%, CO—9.8%, CH_4—0.2%, O_2—none—dried to a dew point of—40°F.

And the reason is clear-cut. KEMP "atmos-gas" units are designed to suit the particular requirements of the particular process.

For example, high-carbon steels are touchy. Too much CO_2 or too much water vapor may cause decarb or scaling during the annealing cycle. In such cases, KEMP "atmos-gas" units incorporate amine scrubbers for CO_2 absorption, and silica-gel towers to desiccate the output.

For treating copper and brass, "atmos-gas" in the low CO range is preferred. The reduction of metallic powders requires quite the opposite.

Where fuel-gas might be "sour", copper gauze strips sulfur from the atmosphere gas.

It all depends on *your* products and *your* processes. KEMP engineers can tell you where you stand in the confusion of claim and counterclaim in this fast-developing business of atmosphere heat treating.

KEMP OF BALTIMORE

PRECISION CARBURETION + ADAPTED COMBUSTION FOR INDUSTRY'S HEAT-USING PROCESSES
ATMOSPHERE GENERATION & ADSORPTIVE DRYER SYSTEMS FOR PROCESS CONTROL AND PROTECTION

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THE COOLING TOWER is one of the most critical pieces of equipment affecting overall plant operation. Despite this fact, comparatively few users of Cooling Towers have ever attempted to determine whether or not the towers purchased were doing the job specified. *The most exacting specifications are useless if the manufacturer's performance guarantees are never tested.*

After years of field tests, under widely varying conditions, we of the FLUOR Corporation have proved to our satisfaction and that of many customers that the Power Test Code, 1929 Series, as adopted by the A.S.M.E., provides the measurement standards necessary for testing any Cooling Tower—regardless of design or make.

Don't take our word for it. Test your Cooling Towers. Or, if you prefer, FLUOR Engineers are available to make an unbiased and unprejudiced test of any Cooling Tower you operate.

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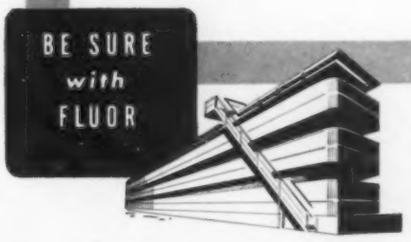

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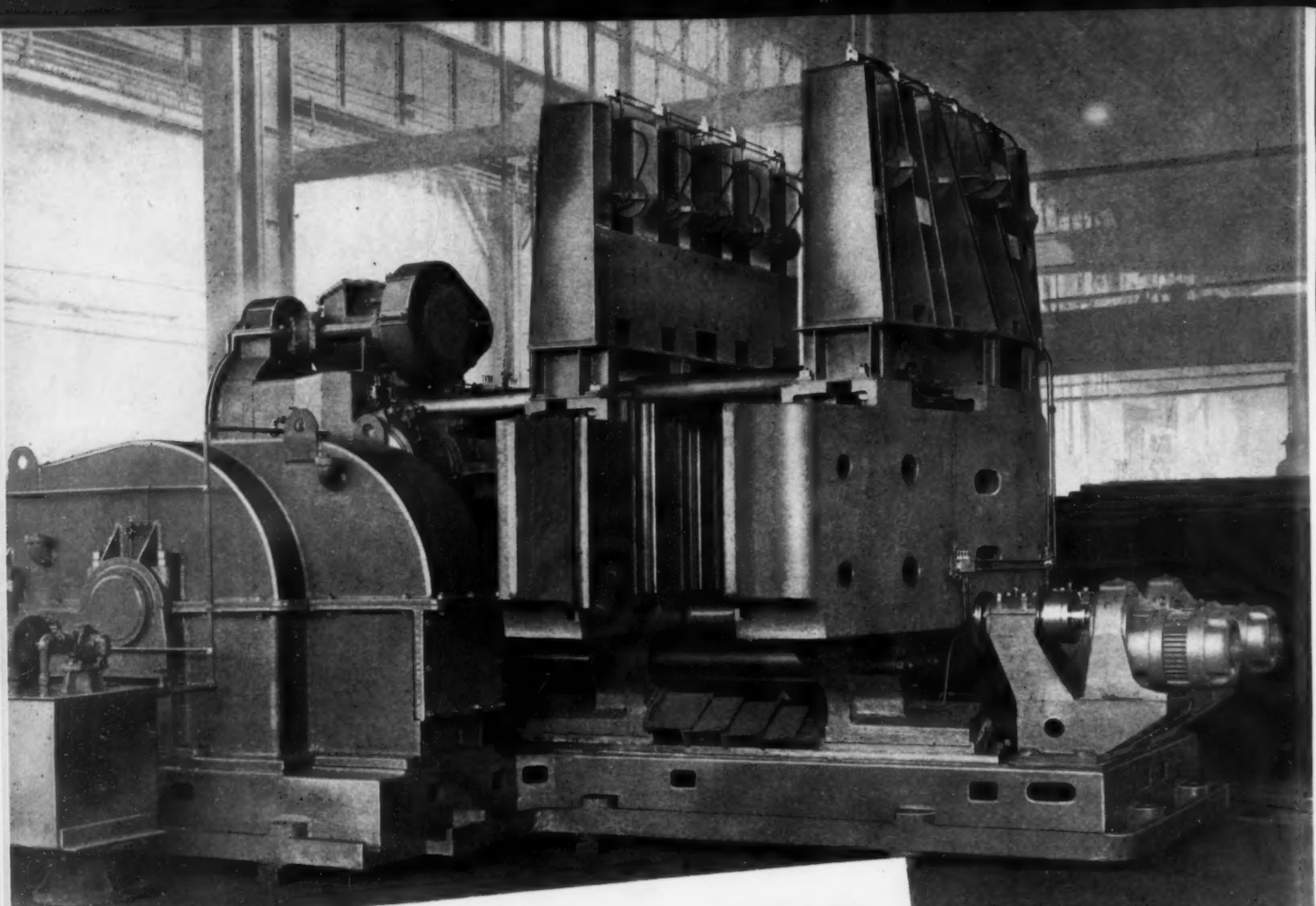

MORGAN GAG PRESS FOR STRAIGHTENING HEAVY ROLLED SECTIONS

● Among the many types of mill equipment built by Morgan, is the heavy duty gag press or straightener illustrated above. It is of massive construction with drive gears and flywheel mounted on roller bearings and all enclosed in an oil-tight welded housing. All anvil blocks are raised and lowered by individual air cylinders. The two feed rollers are driven by individual motors. This press is typical of the many types of Morgan mill equipment

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Personnel News

C. V. Gregory has been appointed district manager in Pittsburgh for The Reliance Electric and Engineering Company. **Bon J. Ballard,** the former manager moves to the post of assistant to the sales vice president.

Under his new responsibilities, Mr. Ballard will continue to make his headquarters in Pittsburgh, where his wealth of experience gathered in selling motors to steel mills over the past 27 years will be available to all sales districts of the company. Mr. Ballard was born in Cleveland but has made his home in Pittsburgh since 1919, when he became district manager for Reliance. He is a member of the Engineers Society of Western Pennsylvania, the Association of Iron and Steel Engineers and the Engineers Civic Club of Pittsburgh.

Mr. Gregory came to Reliance in 1928 upon graduation in engineering from Drexel Institute of Technology, Philadelphia. He has been a sales engineer in the company's Pittsburgh office for the past 16 years. He is a member of the Association of Iron and Steel Engineers.

L. J. Carr, who, prior to 2½ years in the U. S. Naval Reserve, was a sales engineer in Reliance's Chicago office, will join the Reliance staff in Pittsburgh. He is a graduate electrical engineer of Union College, Schenectady, New York.

Walter S. Tower was reelected president of the American Iron and Steel Institute by the directors at the 54th general meeting of the Institute. Other officers reelected are: **B. F. Fairless** and **Frank Purnell,** vice presidents; **Harold L. Hughes,** treasurer and **George S. Rose,** secretary.

W. F. Rockwell, board chairman and president of Rockwell Manufacturing Company, has been elected to the board of directors of United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

A. F. Morris, formerly president of Morgan Engineering Company, Alliance, Ohio, was recently named chairman of the board. **W. H. Morgan, Jr.** succeeded Mr. Morris as president. **A. T. Davis** was named vice-president and sales manager, **C. T. Bertolette** became assistant secretary and treasurer, and **M. E. Rhue** was chosen general production manager.

Carl S. Westerberg became a member of the staff of Bituminous Coal Research, Inc., Pittsburgh, Pennsylvania. Mr. Westerberg, a former employee of Utah Fuel Company and the Illinois State Geological Survey, has been engaged in bituminous coal activities since he was graduated from Knox College in 1931 where he received a bachelor of science degree in chemistry.

J. E. McWilliams was appointed general purchasing agent of the Blaw-Know Company. Mr. McWilliams has been with the company for the past 26 years, and until his present appointment was purchasing agent of the Blaw-Know division of the company at Pittsburgh, Pennsylvania.

George Bottcher was chosen construction engineer for Allegheny-Ludlum Steel Corporation. Mr. Bottcher went with the company in 1940 as a member of the engineering staff. Previously he had worked with the Bureau of Yards and Docks, Navy department, and with the construction division, Corps of Engineers. He was graduated from Cornell University and also attended Montana State University.

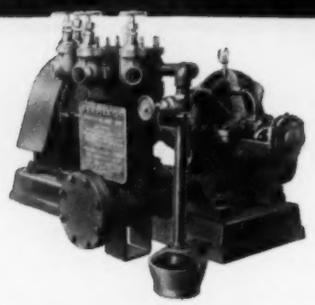
BUD SCOTT PHOTO

Bon J. Ballard, newly appointed assistant to the sales vice president of Reliance Electric and Engineering Company, is shown with C. V. Gregory, the new Pittsburgh district manager, and L. J. Carr, sales engineer.

Earl Genn and **Frederick D. Logan** of Genn and Logan, 3959 North Lincoln Avenue, Chicago, Illinois, have been appointed representatives of the C. M. Kemp Manufacturing Company of Baltimore, Maryland. The principals of the firm of Genn and Logan, which was recently organized, have both been active in the sales and development end of industrial gas utilization for some years.

H. H. Wunderlich, formerly assistant to the executive vice president, has been appointed an assistant controller of the Jones and Laughlin Steel Corporation. Mr. Wunderlich has been with Jones and Laughlin for 23 years, having started with the company in the accounting department. Since 1926 he has served in various capacities in the office of the controller, financial vice president and executive vice president.

FIRE PUMPS
(Underwriters Approved)



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Type AF
Motor Driven
FIRE PUMP

With the recent acquisition of the Dayton-Dowd Company of Quincy, Illinois, Peerless Pumps manufactures a complete line of horizontal and vertical centrifugal and turbine Pumps. The Type AF Motor Driven Fire Pump has long been a leader in a field where dependability is a synonym for protection. Adapted to a wide variety of both motor and engine drives Peerless Fire Pumps have a wide application. Descriptive literature available upon request.

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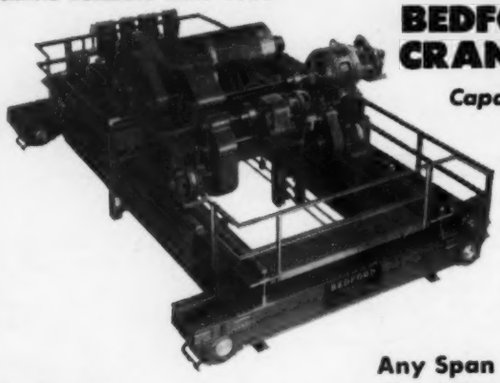

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Capacities 5 to 150 Tons

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GANTRY CRANES • STEEL DERRICKS
BUILT TO YOUR SPECIFICATIONS
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AIRPLANE HANGERS

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Engineers
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Gray Iron Castings

John W. Sheffer, general electrical engineer, American Car and Foundry Company, has been appointed general improvement engineer. In this capacity he will have direct charge of the improvement division with headquarters in New York. Mr. Sheffer has been with the company since 1908, following his graduation from Cornell University with a degree in mechanical engineering. In 1933 he obtained his masters degree from Columbia University. He began his association with the company at the Berwick plant as electrical engineer, and later served in the capacities of assistant to the general superintendent and plant engineer. During these 17 years he was engaged also with welding developments of all description, and was in part responsible for the important advances made in welding at ACF plants.

JOHN W. SHEFFER

Edwin L. Ramsey, superintendent of steel production for Wisconsin Steel Works, Chicago, Illinois has been elected chairman of the National Open Hearth Steel Committee, American Institute of Mining and Metallurgical Engineers. Mr. Ramsey succeeds **A. P. Miller,** general superintendent, Inland Steel Company, East Chicago, Indiana. Mr. Ramsey's election was confirmed at the Annual Meeting of the Open Hearth Executive Board in Chicago on April 24th. His election is for one year, and he will preside at the 30th Annual Open Hearth Conference which will be held in Cincinnati on April 21, 22, and 23, 1947. Mr. Ramsey had been vice-chairman of the Open Hearth Committee and has been active in the work of this group since its inception in 1925.

After graduating as an engineer in 1900 Mr. Ramsey started as a third helper for Carnegie-Illinois Steel Corporation and progressed to melter foreman; subsequently he served as open hearth superintendent for American Steel Foundry Company, Mesta Machine Company, Eastern Steel Company and Wisconsin Steel Works, in that order. He is now superintendent of steel production for the Wisconsin Steel Works, a position he has held for many years.

W. C. Kitto, superintendent steel division, Pittsburgh Steel Company, Monessen, Pennsylvania and former chairman of the Pittsburgh Section of the

National Open Hearth Steel Committee, has been elected vice-chairman. **Frank T. Sisco,** secretary-treasurer of the Open Hearth Steel Conference since 1942, was reelected. **Ernest Kirkendall** was appointed assistant secretary of the National Open Hearth Steel Committee.

JAMES P. STEWART

James P. Stewart has been appointed special representative for De Laval Steam Turbine Company, Trenton, New Jersey. Mr. Stewart, who for many years was connected with the Elliott Company, Jeannette Pennsylvania, was recently the assistant general manager of B-W Superchargers, Inc. division of the Borg-Warner Corporation.

J. K. MAHAFFEY

J. K. Mahaffey and Son have been appointed representatives of the Baker Industrial Truck division of Baker-Raulang Company in the Pittsburgh area succeeding **Criss and Mahaffey.** The new office address is 1006 Pitt Bank Building, Pittsburgh, Pennsylvania.

Mr. Mahaffey, Sr. is well known in the Pittsburgh territory. He has been connected tith the company since early in the war period and previous to that was manager of the Edison Storage Battery Company's

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METAL CUTTING & TRIMMING COSTS FROM DOLLARS TO PENNIES

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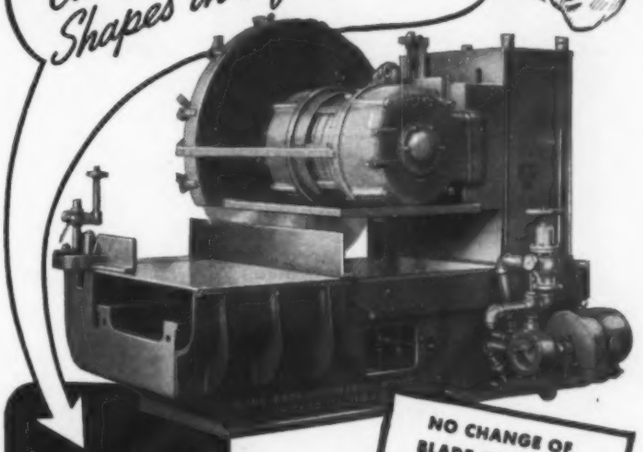

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24" 100# I-BEAM 28 SECONDS
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INCREASES PRODUCTION...
CUTS ALL CLASSES OF STEEL - QUICKLY AND ECONOMICALLY

The versatile ability of the Kling Friction Saw to cut varied structural shapes in any sequence, without change of blade or set-up, permits one machine to handle various types of work which, otherwise, would require several slow speed saws to handle.

The installation of a Kling Friction Saw will quickly convince you of its superiority and advantages over the old type of saw. Furthermore, you will cut your cutting costs — savings will be effected in time and labor because of speed and efficiency of the Kling Saw.

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HERBERT T. FLORENCE

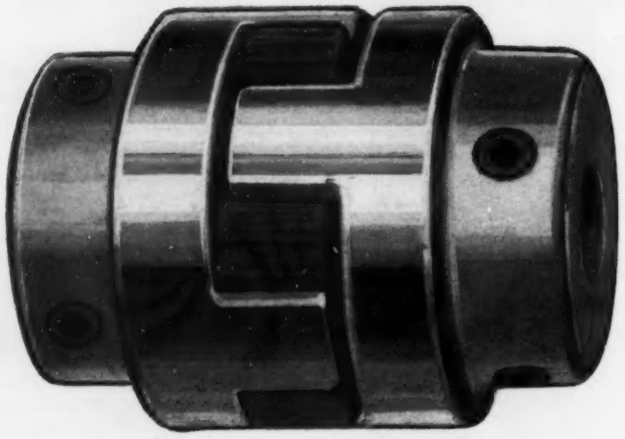
GEORGE F. FERRY

Pittsburgh office for more than 25 years. With Mr. Mahaffey is his son, J. K. Mahaffey, Jr., who was released from the Navy shortly after the first of the year. Jack, Jr., is a Penn State man like his father, and after his graduation he had several years business and selling experience before entering the Navy.

Herbert T. Florence has been elected president and general manage of the Cleveland Crane and Engineering Company, Wickliffe, Ohio. He has been general manager of the company since 1938 and vice president since 1941. **A. C. Garnett,** formerly secretary and treasurer was named vice president and treasurer. **W. G. Wehr,** was made secretary, and **W. D. Vanderbilt,** assistant secretary.

George F. Ferry has been appointed superintendent of standard structural mills at the South Chicago plant of Carnegie-Illinois Steel Corporation, U. S. Steel subsidiary. He recently returned to the plant after

Why This LOVEJOY L-R Coupling is Most Widely Used in America!



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Pat. & Pats. Pend.

By all odds — the best performer in its class! Only 3 simple parts: 2 metal jaws and resilient spider cushion. No lubrication needed. *Quiet*. Best correction of misalignment, whip, surge, shock, backlash, vibration.

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Quick-finding Selector Charts, Engineering Data and Catalog sent on request.

Other Couplings for duties to 2500 hp.

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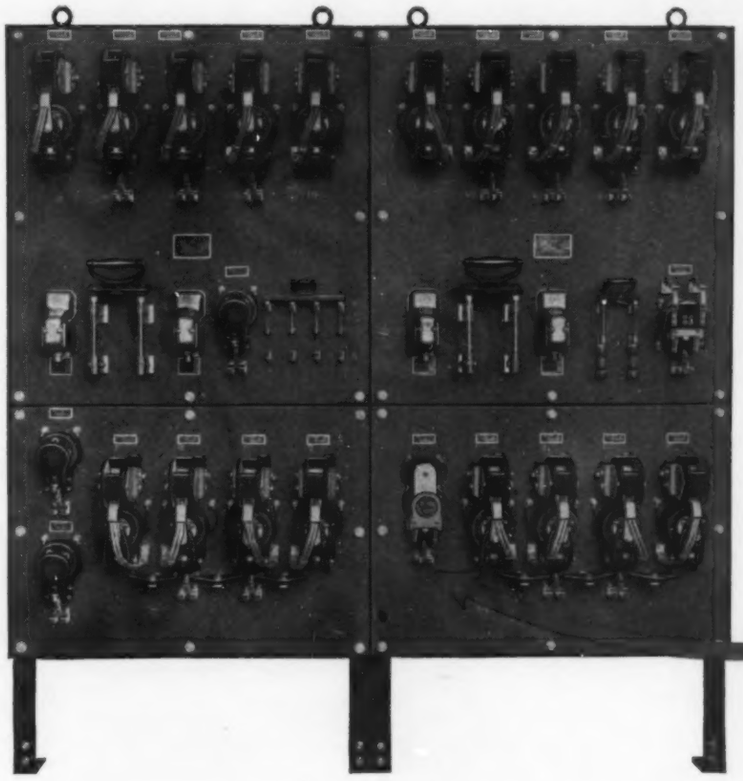
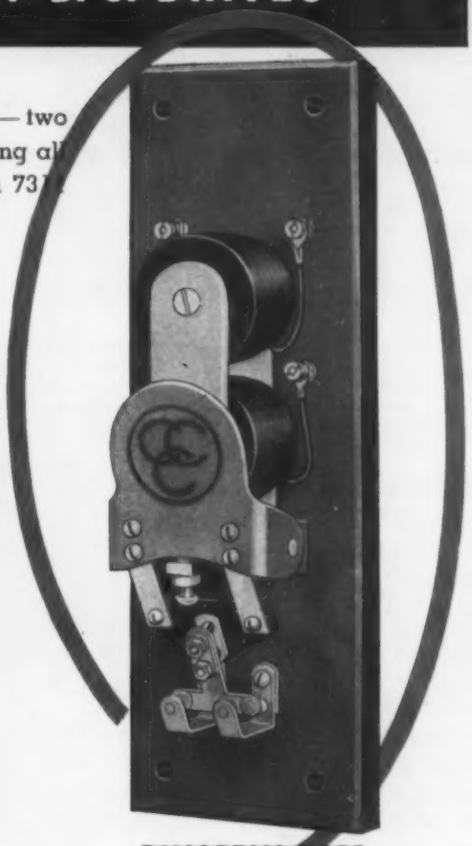
SIMPLE, STURDILY BUILT "3C" RELAY PROVIDES DEPENDABLE "PLUGGING" ON D. C. DRIVES

Simplicity Plus! For the vitally important operation of "plugging"— two identical shunt coils and a set of normally open contacts, duplicating all other circuit control contacts on the panel, are found in Bulletin 731 Type PR Plugging Relays.





BULLETIN 731
TYPE "PR"
PLUGGING RELAY

DUPLEX CRANE
BRIDGE CONTROLLER

In starting from rest, the bottom coil predominates, and the relay closes immediately. However, during "plugging" the top coil has the counter EMF of the motor applied to it in a direction to neutralize the bottom coil. Thus the relay is blocked open until zero speed is reached. At that time, the bottom coil again takes command and the relay closes.

These relays provide accurate, dependable "plugging" operation by a simple easily understood device for such D. C. drives as Crane Bridges, Mill Tables, Manipulators, etc.

THE CLARK CONTROLLER CO.

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BOWSER
ESTABLISHED 1885
filters
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. . . are the result of more than 50 years of Bowser experience in designing and building filters for many industrial requirements . . . always employing the most advanced principles of filtration.

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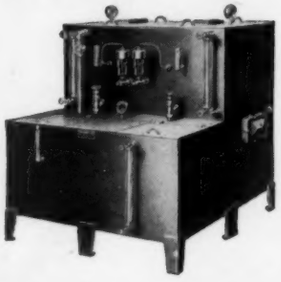

The Bowser Type BB Filter is used to filter and sterilize lubricating, cutting, quenching, hydraulic and other oils. The precipitating and sterilizing operations may be continued as long as necessary or desirable. Dermatitis and other skin infections caused by contaminated oils are effectively checked by the sterilizing feature. Capacities 30 to 480 g.p.h.

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The Fig. 835 is for fine filtration of lubricating oils, fuel oils, steam turbine oils, gasoline, water, petroleum distillates and other liquids. Removes particles as small as 2 microns. The cartridges are easily replaced. Capacities 50 to 300 g.p.m. Also available as Fig. 837 with capacity of 14 to 21 g.p.m.

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A Bowser engineer will be glad to call at your convenience and discuss the specific filtering requirements of your plant. No obligation . . . write today.

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LIQUID CONTROL SPECIALISTS SINCE 1885

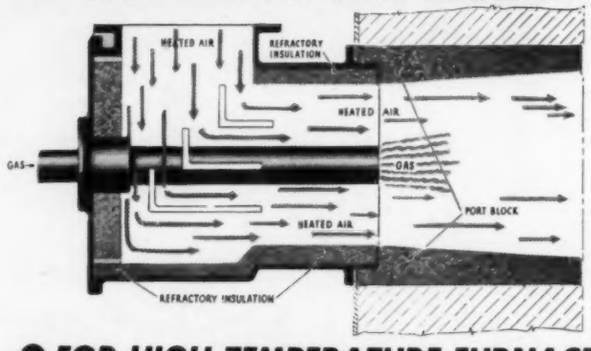
nearly 5 years service with the U. S. Army in World War II.

A graduate of Valparaiso University, Mr. Ferry has had 30 years service with U. S. Steel subsidiaries, most of which have been spent at the South Chicago plant where he started as a clerk in 1919.

PAUL M. JOHNSON

Paul M. Johnson, assistant superintendent of the open hearth department at the Campbell plant of the Youngstown Sheet and Tube Company, has been appointed superintendent of the company's Brier Hill open

BLOOM HOT AIR BURNER



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The Bloom Hot Air Burner is for use with natural gas, coke oven gas, oil, tar or mixed gas, with combustion air at 600°F to 1500°F. It provides the highly efficient luminous flame, characteristic of all Bloom Long Flame Burners. Applications include soaking pits, billet heating furnaces, forge furnaces, melting furnaces, and other high temperature service.

Write for complete information.

BLOOM ENGINEERING CO.
857 W. North Avenue Pittsburgh 12, Pa.

hearth department at Youngstown. Mr. Johnson succeeds **William J. Reilly** who recently left Sheet and Tube to join the Ford Motor Company.

Charles E. Deterding, a Youngstown Sheet and Tube Company employee nearly 33 years and turn foreman in the open hearth department since 1937, succeeds Johnson as assistant superintendent of open hearths at Campbell.

A native of Harrisburg, Pennsylvania, Mr. Johnson graduated from high school there, and then went to the University of Michigan where he graduated in 1926. In 1927 he joined the Minnesota Steel Company at Duluth, went with Illinois Steel Company in South Chicago in 1930, with National Tube Company at McKeesport, Pennsylvania, in 1932 and to the National Tube Company at Lorrain, Ohio, in 1933. Mr. Johnson was turn foreman in the open hearth department at Lorrain in 1944 when he resigned to join the Youngstown Sheet and Tube Company as assistant superintendent of the Campbell open hearth department. He went to Youngstown to succeed Mr. Reilly who had been transferred to the Brier Hill plant.

Obituaries

Harry Hollis, formerly electrical foreman at Bethlehem Steel Company, Lebanon, Pennsylvania, died recently. Mr. Hollis had been an active member of the Association of Iron and Steel Engineers since May 22, 1920. He resided at 25 East Pershing Avenue, Lebanon, Pennsylvania.

W. A. GIVENS

W. A. Givens, 60, executive vice president and director of Allegheny Ludlum Steel Corporation, died at 5:10 P. M. Wednesday, May 29, following a cerebral hemorrhage in his office at Brackenridge, Pennsylvania.

Mr. Givens came to Allegheny Steel Company in 1925 as superintendent of the merchant mill after many years of operating experience with other steel companies. In 1926, he was promoted to alloy production manager and two years later was appointed general superintendent, a position he held until 1932 when he was made general manager. In 1938, he was elected to the board of directors and was made vice president in charge of manufacturing. In 1944, he was elected executive vice president.

ONE HOLDER MARKS 9 SIZES OF TYPE

- For Serial Numbering.
- Marks Brand Name—Lot No's.
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- Special Steel for Safety.
- Sturdy Type Box for Complete Outfit.

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THE PUMP WITHOUT PISTONS, VALVES, BEARINGS, GEARS OR VANES

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The IMO pump has only three moving parts—a power rotor and two sealing rotors—nothing to get out of order or to require adjustment. The IMO pump can be depended upon in hydraulic service, governor service, lubrication service and other applications in which continuity of operation and freedom from maintenance are vital.

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BY BALL AND ROLLER BEARING MAKERS

After exhaustive tests conducted by their own research departments, most of the leading ball and roller bearing makers now recommend NON-FLUID OIL. These tests proved in every instance that NON-FLUID OIL is strictly neutral, thus guaranteeing long life and dependable operation by protecting bearings from pitting and corrosion. Add to this the fact that NON-FLUID OIL outlasts ordinary grease several times and it's obvious why so many machinery builders and thousands of plants have discarded ordinary greases in favor of NON-FLUID OIL — "The Modern Plant Lubricant."

Warehouses: Atlanta, Georgia - Greenville, South Carolina - Charlotte, North Carolina - Providence Rhode Island - Chicago, Illinois - St. Louis, Missouri - Detroit, Michigan
Works: Newark, New Jersey.

50 YEARS OF LUBRICATION SERVICE TO INDUSTRY — NON-FLUID OIL — 1895-1945 — NEW YORK & NEW JERSEY LUBRICANT CO.

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Extra Strength MAGNETS

A 55" Double strength magnet.

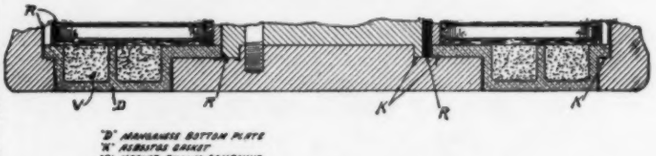
The OHIO 6 pancake coil magnets in the 55" and 65" diameters will average 35% better lifts than the standard magnets.

The OHIO 8 pancake coil magnets will average 75% more than the standard magnets.

Labor cost per ton and time required to handle are both reduced correspondingly.

Numerous repeat orders testify that performance equals or exceeds the statements above.

★When OHIO magnets are required to lift hot materials the heat resisting bottom construction shown below successfully retards the flow of heat from the load to the magnet coil and permits all day use.



"D" MANGANESE BOTTOM PLATE
"K" ASBESTOS GASKET
"R" MAGNET FILLING COMPOUND
"V" HIGH TEMPERATURE HEAT INSULATION

Have you a problem requiring fast lifting or lifting of hot steel?

The OHIO Electric Mfg. Co.

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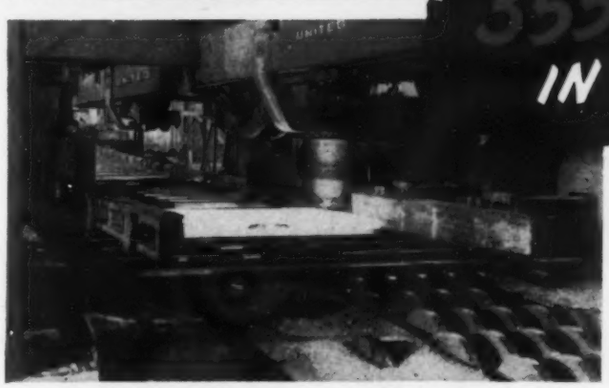
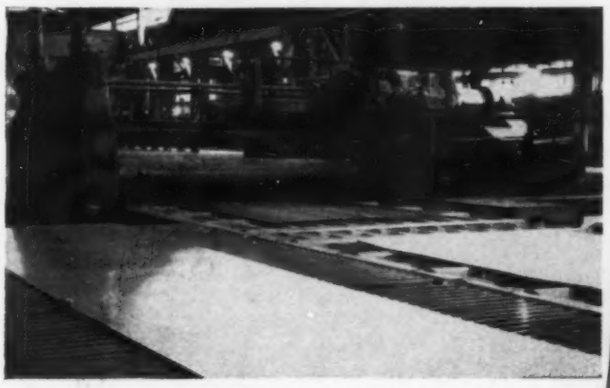
United 120" Plate Mill at Lukens Steel Company.

355 TIMKEN BEARINGS IN MAJOR EQUIPMENT



United Vertical Edger for 120" Plate Mill.



McKay 14" Leveler.

help to keep things rolling in the 120" mill at Lukens . . .

Timken Tapered Roller Bearings are engaged in virtually every steel processing operation in the 120" mill at Lukens Steel Company.

Following is a list of the various kinds of main and auxiliary equipment in which Timken Bearings are applied, with the number of bearings used in each case.

Ingot Car	10 Timken Bearings
Receiving Table	7 " "
112" Mill Edger Approach Table	9 " "
112" Edger Delivery Table	12 " "
42" Vertical Edger	6 " "
112" Intermediate Table	18 " "
120" Mill Front Table "A"	26 " "
120" Mill Back Table "B"	23 " "
120" Mill Attached Vertical Edger	12 " "
120" Mill — Work Roll	4 " "
120" Mill — Screwdown	10 " "
Backup Roll Changing Rig	6 " "
McKay 10" Levelers	36 " "
Ducking Dog Table "J"	5 " "
McKay 8" Leveler	40 " "
120" Mill Transfer Table "T-6"	7 " "
120" Mill Transfer Table "T-5"	14 " "
Plate Centering Device "P" Indicators	5 " "
McKay 14" Leveler	32 " "
120" Mill Transfer Table "T-3"	20 " "
156" Vertical Shear	15 " "
Rotary Shear Drive	4 " "
Rotary Shear Traverse	4 " "
Scrap Chopper Drive	8 " "
Adjustable Side Guards Table "W-2"	2 " "
Plate Centering Device Table "2"	5 " "
	355

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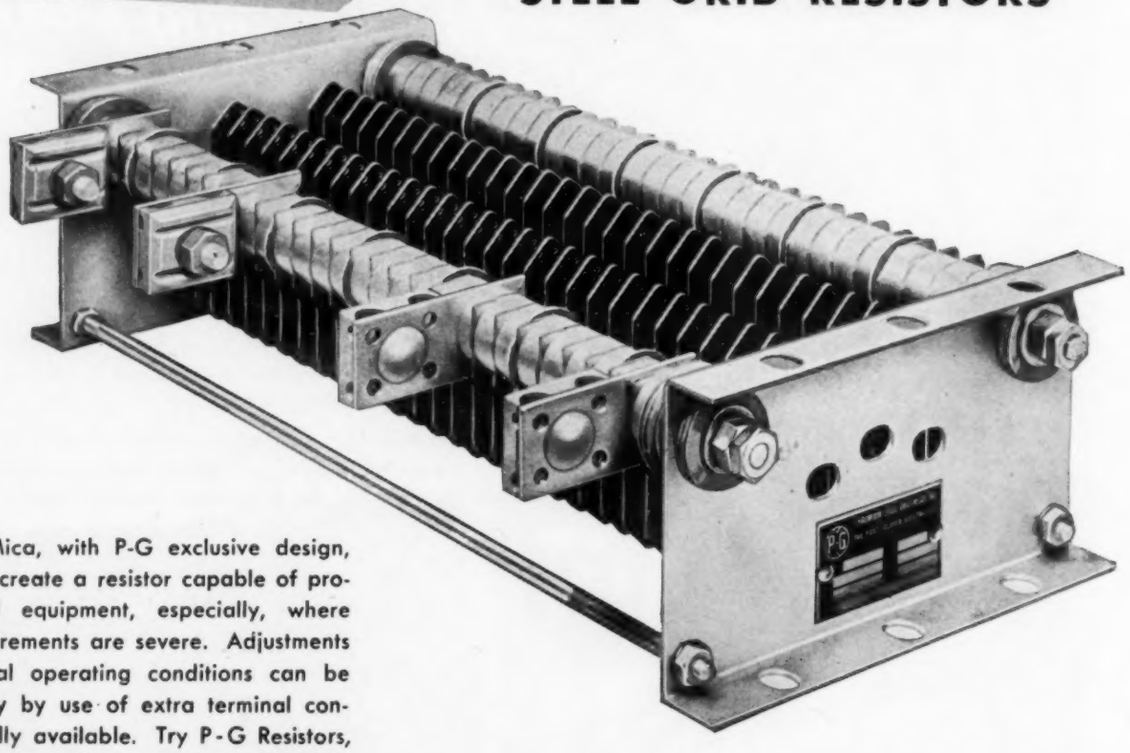

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• ESTABLISHED 1892 •

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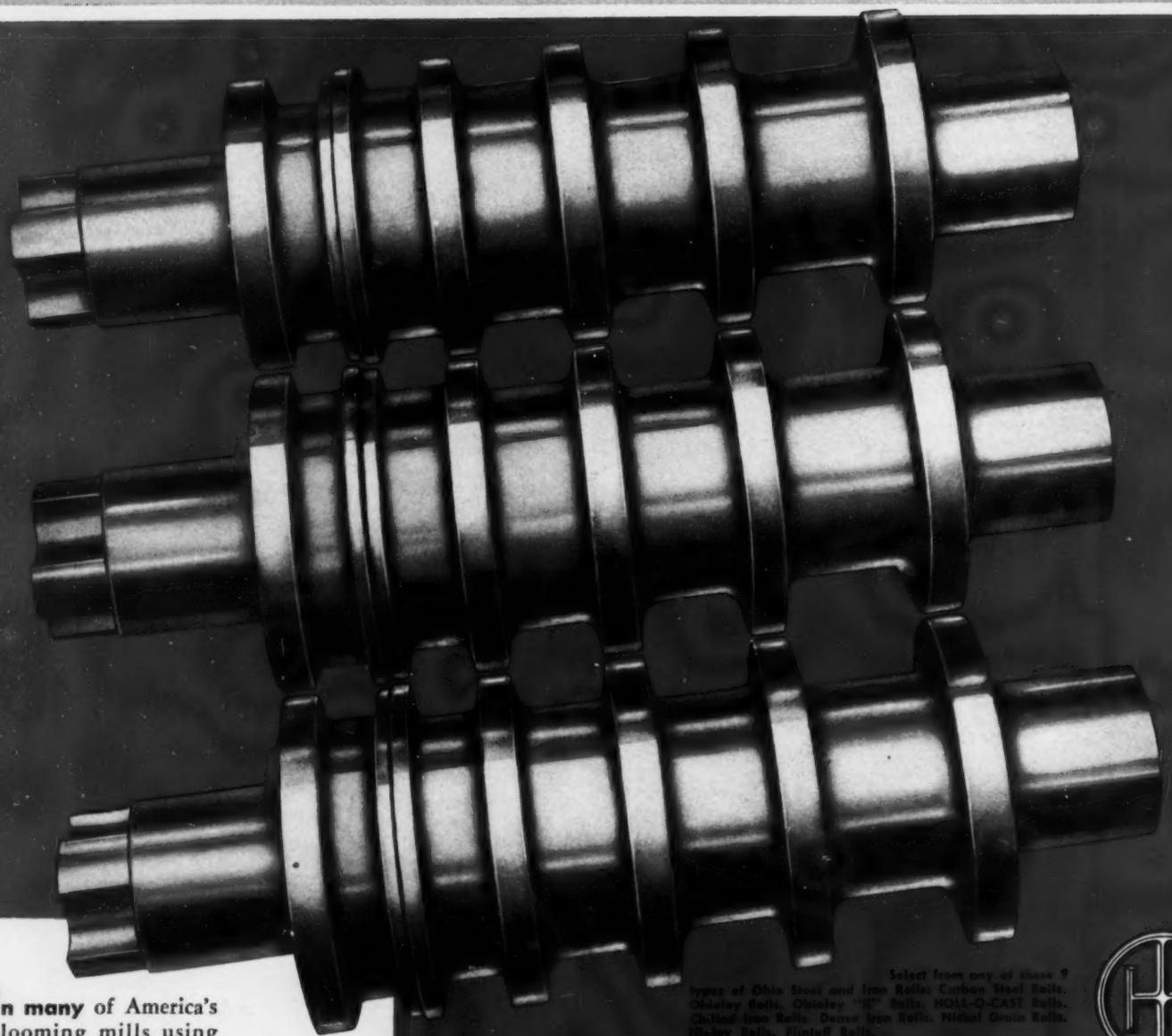

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